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Noyes's College Text-Book of Chemistry

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This *College Textbook of Chemistry* is designed, more especially, for students of the freshman or sophomore years in college who have not studied chemistry in high school. It is considerably briefer than the author's previous *Textbook of Chemistry*, and its style is exceptionally clear and simple.

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The teacher of chemistry is embarrassed by the vast and ever increasing amount of knowledge at his disposal and is often tempted to present many more topics than the student can possibly remember. In trying to avoid this difficulty many facts ordinarily included in an elementary textbook have been omitted and those which are given are brought as far as possible into close logical relations.

The summary at the close of each chapter is a somewhat unusual feature of the book. It is hoped that these summaries will be found useful.

Success in the study of chemistry depends especially on the ability to learn new facts in their relation to those which have already been acquired and on the cultivation of a logical as distinguished from an arbitrary memory. The exercises at the close of each chapter and questions occasionally inserted in the text are designed to assist the student in this direction.



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THE SCIENTIFIC MONTHLY

OCTOBER, 1919

THE ORIGINS OF CIVILIZATION¹

By Professor JAMES HENRY BREASTED

THE UNIVERSITY OF CHICAGO

FROM THE OLD STONE AGE TO THE DAWN OF CIVILIZATION

I.

LINNÆUS was the first natural scientist to find a place for man in the natural system. There is an enormously long stage in the career of man when the study of him is obviously the task of the natural scientist. Much of the work of the anthropologist and psychologist is properly classed as natural science. At a certain stage in the development of man, however, we begin to call the study of him and his works archeology, history, philology, art and literature—lines of study which we sharply differentiate from natural science. I have often wondered what there is unnatural about man. If it could be demonstrated that the pterodactyl was gregarious, built towns, made pottery, carried on industry and commerce, and left behind written records, I fancy that we should still call the study of him paleontology and not divorce it from natural science.

It has been a source of great gratification to the writer that in the William Ellery Hale lectures on Evolution, the career of man has been regarded as a part of the course of nature. The protoplasm is indeed a long way from the idea of liberty and the chimpanzee may antedate by millions of years the conception of social justice, but the transition from the stage of biological to that of social processes is a gradual one, even though we readily recognize that man has finally risen to many qualities and ideas which transcend matter and can not be placed under the microscope or weighed in the chemist's balances.

¹ Delivered before the National Academy of Sciences in Washington, D. C., April 28 and 29, 1919, as the seventh series of lectures on the William Ellery Hale Foundation.

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the hunters of the Paleolithic Age on the south side of the Mediterranean. It is a natural conclusion that the retarding force was the recurring cold and ice by which Europe was so long beset, while the south side of the Mediterranean was enjoying far more genial conditions. It will therefore be necessary for us to investigate what was going on in northern Africa, long before the last glaciation of Europe had retreated. The presence of the great African mammals in glacial Europe, like the southern elephant (*Elephas meridionalis*) whose bones are found on the high terraces of the Seine and the Eure ninety feet above the present river level, demonstrates the connection of Europe with Africa in that distant age. Both at Gibraltar and through Sicily the great European peninsulas of the western Mediterranean were united with Africa by land (Fig. 2).

Just as the wild creatures crossed these land bridges from Africa to Europe and back again, so must the men who hunted them have done. The dispersion of the art of chipping flint implements throughout the contiguous areas of the two continents was a matter of course. Let it be clearly stated, however, that this unquestionable fact does not carry with it the conclu-



FIG. 2. MAP OF INTER-GLACIAL EUROPE. (After Geikie.) Showing landbridges between western Europe and Africa.

sion that the stages of prehistoric culture on both sides of the Mediterranean necessarily kept even pace with each other, and were therefore always contemporaneous. This we know was not true as between North and South America; neither was it true of prehistoric Africa and Europe. When the European Stone Age hunters received metal in the Ægean area about 3000 B.C., it was a thousand years before it had crossed Europe to Scandinavia and the British Isles. To speak of Mousterian flints found in Siberia as necessarily contemporary with those of France, is as absurd as to make Verestchagin, the Russian painter, contemporary with Titian.

The existence of North African man in European glacial times has been clearly demonstrated. The flint implements which he wrought have been found, still lying in strata of quaternary age in Algiers.² In the caves of Gafsa in Tunis Schweinfurth has also found flints of Paleolithic type, but not in stratifications or with a fauna which demonstrates their unquestionable Paleolithic age.³ In the same region, furthermore, Schweinfurth has found artifacts of even pre-Chellean types, lying in deposits of coarse conglomerate (*nagelfluh* or "*poudingue*" Fr.), which the discoverer concludes were of early quaternary date. He found 411 pieces, some of which he classifies as Eoliths and everything else as Chellean or pre-Chellean.⁴

These early Stone Age hunters of North Africa have left more than their stone implements to tell of their existence along the southern shores of the Mediterranean. In Algiers they carved in the natural rock faces rude drawings of the animals they were daily pursuing. One of these prehistoric drawings (Fig. 3) shows us the *Bubalus antiquus*, or ancient buffalo, a creature presumably of quaternary age in this region. This again demonstrates the presence of Paleolithic hunters in North Africa.⁵

It is evident that the Sahara desert during the age represented by such remains, must have been a fertile region, with productive soil and plentiful precipitation. This continued until the latter part of the glacial epoch; but in the last glaciation of Europe the climate along the Nile at least, was nearer that of to-day. Graffiti and Neolithic remains in the western

² See Boule, *L'Anthropologie*, 13, 1902, pp. 109-110, against Forbes, *Bull. Liverpool Mus.*, III., 1901, No. 2.

³ Schweinfurth, *Zeitschr. f. Ethn.*, 39, 1907, pp. 899-915.

⁴ Schweinfurth, *ibid.*, 39, 1907, pp. 137-181.

⁵ Pomel, *L'Anthropologie*, XI., also Obermaier, "*Mensch der Vorzeit*," p. 168.

Sahara would indicate its habitability, however, in time relatively recent, as the Neolithic of this region seems to have continued almost down to modern times.⁶ Gautier concludes that the changes here have not been due to alteration of the climate during the last two thousand years, but to desiccation caused by dunes, cutting off the Sudan from the Sahara, and resulting in its absorption by the Berbers from the north.

The probabilities certainly are that fertile conditions in the Sahara during the major portion of the Pleistocene permitted the distribution of the Paleolithic hunters from Algiers to the



FIG. 3. ROCK GRAFFITO OF THE WILD BUFFALO (*Bubalus Antiquus*) IN ALGIERS. Carved by prehistoric hunters in the Palaeolithic Age. (After Por.)

Nile. But the Nile of that period offers a geological history which we must have in mind, because it went hand in hand with the career of man in northeastern Africa.

During or just before the formation of the lower levels of the Upper Pliocene, while the Mediterranean coast line was at the site of later Cairo, two extensive fractures occurred, varying from 7 to 24 km. apart. They extended southward from the coast some four hundred miles to the vicinity of Keneh, forming what is called a "block fault" in the earth's crust. As the block between the fractures sank it formed a great rift

⁶ E. F. Gautier, *L'Anthropologie*, 18 (1907), pp. 37-68, 314-332.



FIG. 4. MAP OF THE EGYPTIAN RIFT IN PLIOCENE-PLISTOCENE TIMES. (After Blanckenhorn.)

or trench, stretching from the sea shore at the site of modern Cairo in latitude 30° N., to Kenh in latitude $26^{\circ} 7'$ N. (Fig. 4). The entire rift is in the Eocene limestone. Other more local faults of varying origin carried the rift above Thebes, south of which (at Gebelen) it narrows. Measured along its bends the entire trench is almost 450 miles long. (Railway distance from Cairo to Luxor is 416 miles, and Gebelen is over 17 miles above Luxor.)

As Blanckenhorn, to whom we chiefly owe these facts, has shown,⁷ the rift was open to the sea, which entered and penetrated as far south as Dahaibe, then about ninety miles from the sea shore. Here must have been for a time the earliest mouth of the Nile. But this was much later. The intrusion of the sea fell in the transition from the upper Middle Pliocene to

⁷ Blanckenhorn, "Geschichte des Nil-Stroms," in *Zeitschrift der Gesellschaft für Erdkunde*, 1902, pp. 694-722 and 753-762.

the lower Upper Pliocene. It was contemporaneous with the beginning of increased precipitation in the Upper Pliocene, followed by the rainy transition period from the Pliocene to the Pleistocene, which Hull has called the Pluvial Period.

The narrow connection of the new Egyptian fjord with the sea was early largely blocked and the rapidly gathering fresh water of the east and northeast African drainage soon filled the rift and formed a large lake or series of lakes stretching from the region of Thebes to the sea. Into this lake or lakes plentiful streams flowed from east and west, carrying into the great trench extensive masses of conglomerates, gravels, marls, limestones, etc., which covered the bottom of the trench, and formed also in massive terraces of alternating limestone and indurated gravel along the walls of the rift (Fig. 5).

The characteristic fossil contained in these deposits is the lacustrine mollusc *Melanopsis*, the period of whose prevalence in this region seems to correspond to the already climatically cooled Upper Pliocene and Early Pleistocene especially of the first glaciation in Europe. This is at least the current and probable hypothesis. Accepting this probability, the earliest, that is to say the lacustrine, terraces of the Egyptian trench belong to late Pliocene and early Pleistocene times.

In the immediately succeeding drier period, corresponding to one of the early glacial periods (perhaps the first Inter-Glacial), the Nile stream for the first time appeared in this Egyptian rift. From this time on, river terraces were formed along its banks, though in relatively limited extent. Two of these river terraces can be discerned between the lacustrine terrace above and the alluvium below. The *higher* river terrace is from 6 to 30 m. (along its lower edge) above the level of the

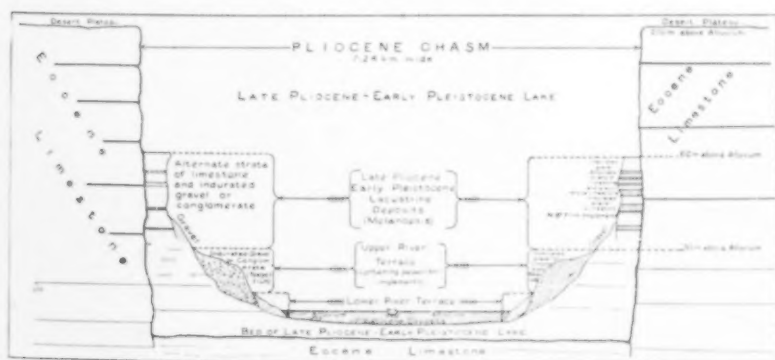


FIG. 5. SCHEMATIC CROSS-SECTION OF THE EGYPTIAN RIFT.

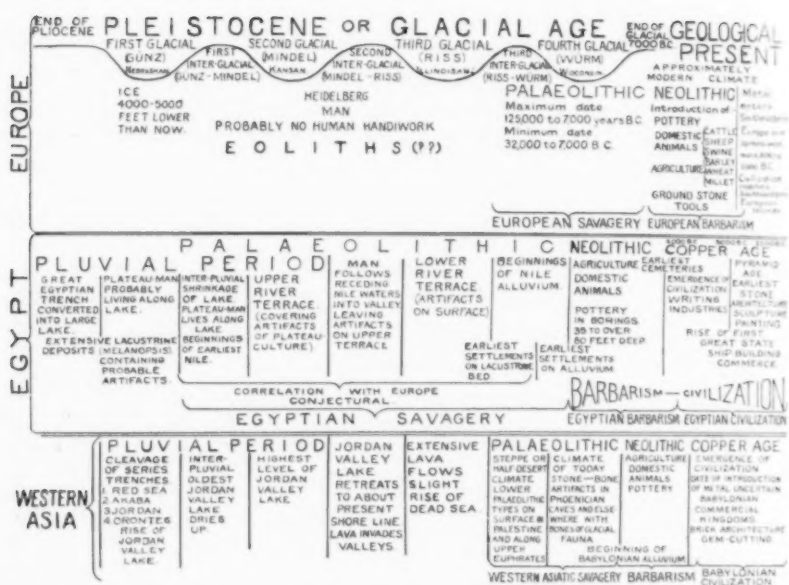


FIG. 6. DIAGRAM SHOWING ATTEMPTED CORRELATION OF GLACIAL EUROPE AND EGYPT.

alluvium; the *lower* is only 9 to 10 m. above the alluvium. The lower of the two is not everywhere observable or distinguishable, for like the typical Nile alluvium it also is made up of Nile mud, sand and fine gravel, without any coarse rubble, and it emerges as a more or less wide, gentle slope along the edge of the cultivated land, and is therefore not sharply distinguished from the latter.

The fauna of these Pleistocene deposits is confined as a rule to shells of fresh-water molluscs still living in the Nile. To these may be added only one extinct variety, the *Unio Schweinfurthi* (Martens). Very few remains of mammals have been found in deposits of this age, but they include buffalo horns and teeth of the hippo and elephant, while the marly lake deposits of the Fayum have yielded teeth, hoofs and leg bones of the horse. With these was also found the mandible of a man, later unfortunately lost. A comparison of this fauna with that of Syria has led Blanckenhorn to the conjecture, if not to the conclusion that in these southern lands, especially Egypt, there did not develop a pleistocene fauna analogous to that of glacial Europe—as if the climatic conditions, at least in the later Pleistocene, the time of prehistoric man, were not so different from those of to-day as in glaciated Europe.

After the formation of the two river terraces shown in the

cross section (Fig. 5), the Nile began laying down the present alluvial floor of the valley. For the deposit of this deep stratum of alluvium, varying from some thirty feet in depth at Thebes to over a hundred or even over a hundred and thirty feet in the Delta, it is evident that the relatively brief period since the retreat of the ice in Europe was quite insufficient. Blanckenhorn estimates that the lower half of the clayey sands and sandy clays forming so much of the Nile alluvium was deposited during the last glacial period of Europe.

To summarize, it will be seen that the geology of the Nile valley, in so far as it bears on the age of man there, displays four chief periods: I., The Lacustrine Terraces (= Pliocene and First Glacial?); II., The Upper River Terrace (= Second Glacial?); III., The Lower River Terrace (= Third Glacial?); IV., The Alluvium, Lower (= Fourth Glacial), Upper (= Post-Glacial?).

In view of the probability that the Lacustrine (Melanopsis) stage reaches over into the First Glacial, and the certainty that the lower Alluvium reaches back into the Fourth or Last Glacial it is tempting to make the Second and Third Glacial correspond respectively to the two River Terraces (Fig. 6). The four glacial ages would then be parallel with the four main periods disclosed by the Nile deposits. These geological parallels are in no sense vital to this presentation, however, with the exception of the conclusion, clearly demonstrated by Blanckenhorn, that



FIG. 7. THE NILE VALLEY ALLUVIUM AT SIUT, seen from one of the lower river terraces.



FIG. 8. THE NILE VALLEY ALLUVIUM AT SIUT, WITH RIVER TERRACE IN FOREGROUND.
(Photograph by Underwood & Underwood.)

the Lower Alluvium corresponds to the European Fourth Glacial.

Turning now to the Nile valley as we find it to-day, the view of Siut in Fig. 7 furnishes a characteristic prospect across the black alluvial floor of the Nile valley from the distant cliffs in the east, to the western cliffs from which the photograph is taken. As we step back up the slope, we include within the range of the camera one of the lower river terraces seen in the foreground of Fig. 8. Again the cliffs near Der el-Bahri at Thebes display characteristic formations of the Lacustrine Terraces, above those of the river (Fig. 10).

These terraces are clearly correlated in a geological map of the western cliffs of Thebes by Schweinfurth (Fig. 9). The band below shows the extent of the cultivated land, the alluvium; the next band above it represents the river terrace, presumably the upper, the lower disappearing at this place, while the uppermost band shows the situation of the lacustrine terraces. According to Blanckenhorn, it will be recalled, these lacustrine deposits, characterized by the fossil mollusc *Melanopsis*, were laid down in late Pliocene-early Pleistocene times; the upper levels therefore may belong in the First Glacial

Period of Europe. At that time the Sahara plateau was habitable, and discoveries of Schweinfurth would indicate that probably as early as the European First Glacial Period, men able to produce flint implements lived along the margin of the cliffs, above the lake here at Thebes.

If Schweinfurth is correct the rude artifacts produced by these men were carried by the drainage from the shores of their plateau dwellings into the lake, where they are now embedded deep in the lacustrine terraces below the brow of the cliffs. He



FIG. 9 GEOLOGICAL MAP OF WESTERN THEBES. (By Schweinfurth.)



FIG. 10. THE LACUSTRINE TERRACES NEAR DER EL-BAHRI ON THE WEST SIDE AT THEBES. The levels containing artifacts are marked with a cross.
(After Schweinfurth.)

has found them below several alternate strata of limestone and indurated gravel, which have collected some fifty feet or more above the artifacts (Fig. 10).

One form believed by Schweinfurth to have been produced by the hand of man displays the familiar "bulb of percussion"; while the edges show evidences of secondary flaking (Fig. 11). The fact that this region was never visited by the ice, makes it more probable that such flints were produced by man, in the absence of the grinding, the pressure and other forces of the ice, to which the European "eoliths" were subjected.

However this may be, it is certain that far back in the European Glacial Age the North African plateau was inhabited as we have already seen. Inhospitable as the stretches of the desert along the Nile valley now look, they were once the home of man. These early plateau hunters have left traces of their presence other than their flint weapons. In 1906 a native at Abu Simbel in northern Nubia assured me that he could take me out into the Sahara to an unknown temple of which so many vague reports had reached archeologists that it had long been known to us as "the lost temple." Several hours march from the Nile, far out in the western desert, we did indeed find it

(Fig. 12). It proved to be a natural rock formation, with a door wrought also by nature, and alongside the door the records which the natives had reported as inscriptions proved interesting enough. Here were carved two boats, two giraffes, two ostriches and a number of smaller animals. The giraffe has been extinct in Egypt from very remote times, and it is possible that the hunters of Pleistocene Age have left these records in the Sahara.

Just above Thebes along the crest of the cliffs behind the Kings' Tombs (Fig. 14), these early hunters had a number of workshops, and here worked flints are still scattered so plentifully that there are stretches kilometers long, where one literally walks on artifacts, and it is difficult to find a piece of flint produced by nature. The date of artifacts found thus lying on the surface is not to be determined by the shape, workmanship and type alone. Fortunately these same artifacts may also be stratigraphically dated in the immediate vicinity.

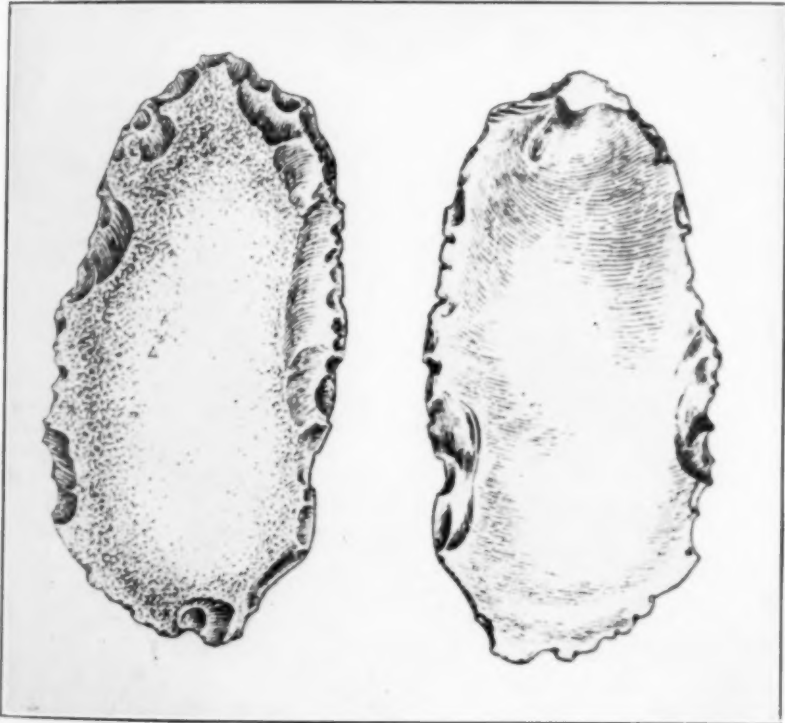


FIG. 11. HUMAN ARTIFACT FOUND WITH MANY OTHERS BY SCHWEINFURTH IN THE LACUSTRINE TERRACES OF THE NILE RIFT. They lay some fifty feet below the surface, at the point marked with a cross in Fig. 10.



FIG. 12. THE SO-CALLED LOST TEMPLE BEHIND ABU SIMBEL IN LOWER NUBIA.

As the great Egyptian lake shrank and the earliest Nile current began to move northward in the old bed of the lake, the drainage of the latter part of the Pluvial Period carried large masses of the neighboring rock rubbish into the valley, and



FIG. 13. THE HEIGHTS OF THE SAHARA PLATEAU ABOVE THEBES. Extensive flint workshops of Quarternary age have been found lying on the surface of the plateau.

these materials helped to form the Upper River Terrace. They carried down with them numbers of the flint artifacts already lying on the plateau, and these early works of man are now found embedded in the conglomerate and indurated gravels of the Upper River Terrace. They were first noticed by Gen. Pitt-Rivers as far back as 1881, at a spot marked with a cross by Schweinfurth on his map (Fig. 9) near the mouth of the wadi called el-Wadiyên ("the two wadis") north of Seti I's Temple of Kurna, on the road to the Kings' Tombs.

Little attention was paid to Pitt-Rivers' discovery; but over twenty years later Schweinfurth placed its correctness beyond



FIG. 14. ROCK-HEWN TOMB COURT KNOWN AS "SAFT EL-LEBEN." In the conglomerate walls of this court artifacts carried down by the drainage in Pleistocene times from the plateau above have been found. (Photograph by kindness of Winlock.)

all doubt. He found artifacts embedded in the strata of this river terrace at Kurna all along the lower end of the Wadiyên, and likewise in the neighboring large courts of the Egyptian tombs here. These courts are some 75 m. square, open on one side and with about twenty-five tomb doors cut in each of the remaining three sides (Fig. 14).

The investigations of Winlock of the Metropolitan Museum have made it extremely probable that these large courts and their arrangements belong to the Eleventh Dynasty (2160-2000 B.C.); that is to say they are over four thousand years old. The entire court and the tombs the doors of which are visible in



FIG. 15. RIVER TERRACE ALONG THE NILE AT THEBES. Here the plateau hunters lived when they shifted from the plateau down into the Nile Rift. (Photograph by Underwood & Underwood.)

Fig. 14 were therefore excavated from a conglomerate or "nagelfluh" formation, hard enough for such excavation over four thousand years ago. Here are thousands of square yards of wall surface embedded in which large numbers of flint artifacts may be found. It requires considerable effort with cold chisel and hammer to disengage these works of early man, thus embedded in a late rock formation.

The materials of which this conglomerate is composed show clearly that they came from the neighboring heights; and their situation at the lower end of a wadi leading down from the plateau leads to the same conclusion. Finally the artifacts contained in the formation are of the same types and workmanship as those found still lying on the plateau. The remains of man found in this terrace belong therefore to the plateau culture, and to a period of that culture long antedating the formation of the terrace.

When the Theban river terrace containing these artifacts was forming (compare Fig. 5), the earliest Nile was at least 15 to 20 meters (over 45-60 feet) above its present highest level. As the river declined in volume, probably during the Second Inter-Glacial of Europe (see Fig. 6), the plateau hunters began to

shift into the valley itself, and to occupy the stretches of terrace on the river's brink. Primeval forest alternated with marsh and jungle along a raging flood of the vast river. Here on the dry and exposed rubble heaps the plateau hunters took up their dwellings. They gradually transferred their flint workshops to the brow of the upper river terrace. Here their flint implements are still found lying on the surface (Fig. 15).

Their hearths and doubtless later their wattle huts were distributed along the river terrace not far from the cliffs behind; for the vantage ground between the foot of the cliffs and the river must have been scanty at first. It was natural that they should scratch their hunting records on the rocks of the cliffs behind their homes, and it is doubtless to this stage of human life in the Nile valley that we owe many of the game animals pictured on the rocks. At a somewhat later stage the reed floats which the former plateau hunters had learned to make for crossing the river along which they had now established their dwellings, were displaced by primitive wooden boats, the earliest known. Of these also, the hunters have carved rude pictures on the walls of the Nile rift (Fig. 16). The great age of these cliff pictures is interestingly shown by the fact that the areas cut away by the



FIG. 16. CLIFF PICTURE OF A PRIMITIVE NILE HUNTER'S RUDE WOODEN BOAT. The earliest wooden craft known, cut on the cliffs at el-Kab. (After Green in *Proceedings of the Society of Biblical Archaeology*, Vol. XXV.)

ancient hunters in carving these figures are covered with a dense blackish brown patina, the somber raiment worn by all rocks in the desert and called by Walther "desert varnish." According to Lucas⁸ it is due to oxides of iron and manganese dissolved out of the stone by the rare rains and the dews, and changed on the surface by the heat into ferric oxide and manganese dioxide, which are insoluble and dark colored. The same conclusion was earlier published by Lortet and Hugounenq⁹; but Linck, on the contrary, maintains that the patina is due to a fine dust deposited by the winds, and adhering finally firmly to the surface, and that it comes from without, not from within the stone.¹⁰ However this may be, surfaces cut away in making hieroglyphic inscriptions some 4,500 to 5,000 years ago, have in this long interval gathered but slight traces of this desert varnish. We must conclude therefore that its presence on the cut surfaces of the prehistoric cliff pictures, if it does not demonstrate, is at least in harmony with, a very remote date for the hunters who wrought these earliest records in the Nile valley.

As the flint implements still lying on the surface show us, these earliest Egyptian hunters were advancing to occupy more and more of the valley, as the waters of the river receded. When the Nile had finally sunk to its present bed, these prehistoric Nile dwellers settled upon its shores. Often they must have dwelt directly on the dry rubble heaps and stretches of sand and clay, which once formed the bed of the Pliocene Egyptian lake. Then the river began laying down the alluvial floor which has now covered the remains of these prehistoric settlements on the old lacustrine bed of the valley. There they lie with thirty feet of alluvium over them, and there it will be impossible ever to recover them.

Thus in the Fourth Glacial Period of Europe the Nile began to deposit the fertile alluvial floor which now forms Egypt (Fig. 7). As this floor gradually spread on each side of the river, it greatly improved the conditions under which the Nile dwellers lived, and while the hunters of Europe were contending with cold and ice, these men of northeastern Africa were enjoying a mild climate, of unequaled salubrity, and likewise

⁸ "The Blackened Rocks of the Nile Cataracts," Survey Dept., Ministry of Finance, Cairo, 1905.

⁹ "Coloration noire des rochers formants les cataractes du Nil," *Comptes rendus, Acad. Sci.*, Tome 134, 1902, p. 109.

¹⁰ Linck, "Ueber die dunklen Rinden der Gesteine der Wuesten," *Jenaische Zeitschr. f. Naturwissensch.*, 35, 1900, pp. 329-336; quoted by Schweinfurth in *Zeitschr. f. Ethn.*, 35, 1903, p. 815.

freedom from the formidable mammals which confronted the European hunters.

Proof of the existence of these remote prehistoric settlements on the lower alluvium is not wanting, although it has thus far been found only in the general latitude of the southern apex of the delta. From 1851 to 1854 L. Horner sank ninety-five pits and borings down through the alluvium in this region.¹¹ "In a large majority of the excavations and borings, the sedi-



FIG. 17. PROSTRATE COLOSSAL PORTRAIT OF RAMSES II. AT MEMPHIS.

ment was found to contain, at various depths and frequently at the lowest, small fragments of burnt brick and of pottery." We know that burnt brick could not possibly have existed in the days of the dwellers on the lower alluvium, and Horner's "burnt brick" must therefore have been simply larger fragments of pottery. His shafts around the colossal statue of Ramses II. at Memphis (Fig. 17) disclosed the lower courses of the substructure supporting the statue. He also reached the bottom of the substructure under the obelisk of Sesostri I.

¹¹ See L. Horner, "An Account of some Recent Researches near Cairo, undertaken with the View of throwing Light upon the Geological History of the Alluvial Land of Egypt," *Philosophical Transactions of the Royal Society*, Vol. 145, 1855, pp. 105-138, and Vol. 148, 1858, pp. 53-92.

at Heliopolis. His measurements enable us to compute the rate at which the alluvium has accumulated in this latitude during the last three or four thousand years. Since about 1950 B.C. the rate of accumulation at the obelisk of Sesostris I. has been about 3.90 inches per century, while at the Memphite colossus of Ramses II., since the thirteenth century B.C., it has been about 4.08 inches. There is a slight margin of uncertainty due to our ignorance of the exact ancient level of the alluvium on the substructures and our ignorance of the exact dates of the monuments.¹² The borings in the latitude of the obelisk, but on the opposite side of the Nile brought up pottery from depths as great as fifty feet, or even nearly sixty feet. Using the rate of accumulation for the latitude of the obelisk, we gain a date of about 15,641 to 18,410 years before 1854 for the people of the lower alluvium. That is, the indications are that these earliest makers of pottery lived from 15,700 to 18,500 years ago.

Even larger figures than these would result from computations based on the discovery of pottery in the lower alluvium at a depth of 22 meters at the southern apex of the delta by Linant Bey; or at 27 meters on the Mahmudieh Canal by Abel.¹³ On the Damietta branch in the delta Schweinfurth reports a human skull found at a depth of 24 meters.¹⁴ It will be seen that the results of computation based upon such facts as these accord very well with Blanckenhorn's demonstration that the alluvium of Egypt began to be laid down long before the end of the last European glacial period, some eight or ten thousand years ago.

The earliest settlements on the old lake bottom and along the gradually widening strip of earliest alluvium have been deeply buried by the thick stratum of the upper alluvium which now floors the valley and covers the whole space between the river terraces (Fig. 18). There lies buried all that remains of the story of an advance through the possession of pottery, the gradually acquired ability to cultivate the wild grasses, the ancestors of our own cultivated cereals, and also the conquest of the wild life and its transformation into our domestic animals. The men who accomplished these things gradually reclaimed the jungles of the Nile rift, and as the valley then enjoyed but scanty rainfall, they began to cut the first trenches

¹² Horner's calculations of the rate are vitiated by the incorrect dates for the monuments themselves current in his day.

¹³ DeMorgan, "Recherches sur les Origines," I., Paris, 1896, p. 19.

¹⁴ In Blanckenhorn, "Geschichte des Nilstroms," *Zeitschr. der Gesell. für Erdkunde*, 1902, 761.

for the irrigation of their little fields, the predecessors of the irrigation canals which we survey from the top of the Great Pyramid. Thus these earliest Nile dwellers slowly shifted from the life of hunters to that of tillers of the soil and breeders of flocks and herds.

As generation followed generation it was found to absorb too much of the cultivable area to bury the dead in the alluvium. They therefore began to make their cemeteries just outside of the alluvium, along its margin. As the rising alluvium spread



FIG. 18. THE SURFACE OF THE PRESENT UPPER ALLUVIUM OF THE NILE VALLEY. Now covering the remains of the earliest human settlements on the floor of the rift or lake bottom,—as seen from the top of the Great Pyramid. (Photograph by Underwood & Underwood.)

out over the valley across the old lake bottom, these cemeteries were covered up in their turn. There can be little doubt that they stretch in a long wandering line, roughly parallel with the edge of the alluvium which now covers them. They are not below the limit of excavation—at least the later ones would be within reach of the excavator, if they could be located. Excavation would then be quite feasible. The problem of determining the location could be solved by boring, and this should be begun on a large scale all along the margin of the alluvium, in the endeavor to find a cemetery. A single cemetery

thus discovered might reveal to us the pottery, stone implements, probably cultivated grain and even domestic animals as well as the bones and skulls of an Egyptian community thousands of years older than any predynastic community now known to us. It would furnish us with a single mile post between the Egyptian whose stone implements we have found on the river terraces, or whose pottery has been disclosed by the borings already mentioned on the one hand, and on the other the prehistoric Egyptian in possession of grain, domestic animals and metal as we find him in the earliest cemeteries now known.

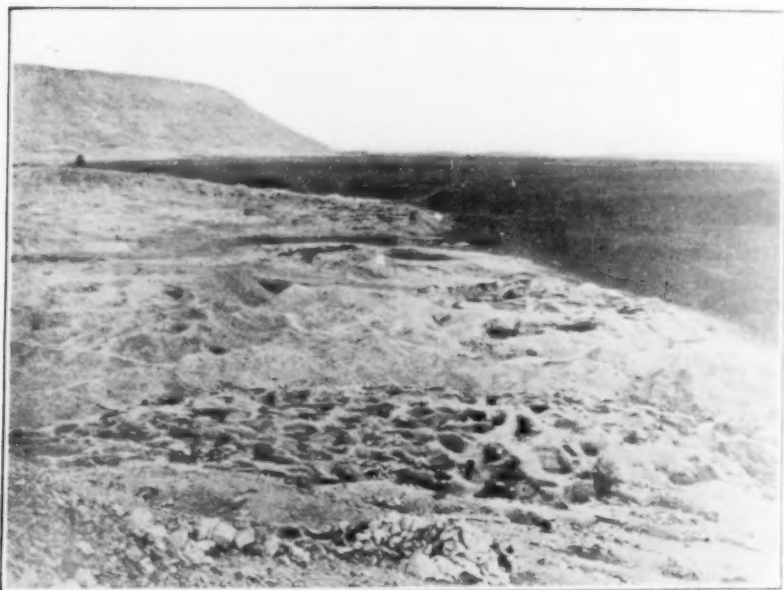


FIG. 19. A GROUP OF EARLY EGYPTIAN CEMETERIES ALONG THE RIVER TERRACE. Just outside the Margin of the Alluvium. (After Reisner, "Naga el-Deir," pl. 20.)

The supposition that the cemeteries of the lower alluvial period were placed along the margin of the alluvium and just outside it, is based on good evidence. The earliest cemeteries known occupy this very position (Fig. 19). When they were first discovered about twenty-five years ago (1894-5), they suddenly revealed to us a group of pre-dynastic Egyptian communities, the earliest of which were already acquainted with metal (copper), though it was not yet plentifully used for implements. These cemeteries therefore represented an outgoing Neolithic stage. A quarter of a century of excavation among

these cemeteries has not yet carried us back into a pure Neolithic stage of culture. Must we therefore suppose that there never was any pure Neolithic culture in the Nile valley?—that the uninhabited Nile rift was invaded by outsiders already acquainted with metal?—and that for this reason the cemeteries of a metal-using people suddenly begin some centuries before 4000 B.C.? If we answer this question in the affirmative, we must assume the extinction or emigration of the pottery-makers disclosed by the borings in the lower alluvium. A population which had earlier maintained itself for many thousands of years along the Egyptian rift from the days of the plateau hunters, through their descent to the river terraces, until their occupancy of the lower alluvium and the discovery of pottery—after this enormously long occupation of the region—can not be conceived to have disappeared from northeastern Africa, leaving it uninhabited until some centuries before 4000 B.C.

It is consequently impossible to conclude that the pre-dynastic cemeteries begin suddenly and abruptly, marking the reappearance of man in the Nile rift after a period of thousands of years without any human inhabitants there. We must conclude, therefore, as we have done above, that the cemeteries which might reveal the successive earlier stages of a pure Neolithic, pre-metallic culture, bridging the present gap between the pottery-makers of the lower alluvium and the earliest pre-dynastic cemeteries now known, will be found under the present margins of the alluvium. Indeed my friend Mr. A. M. Lythgoe, of the Metropolitan Museum, while he expressed some reserve toward the above hypothesis when I proposed it to him, at the same time told me that he knew of one of the earlier cemeteries of which one edge was covered by the alluvium.

While there is a gap in our knowledge between the men of the lower alluvium revealed by the pottery of the borings and the men of the cemetery burials, it is evident that during the period represented by this gap the favored hunters of the Nile valley, not being exposed to the ice and cold of glaciated Europe, were able because of this sheltered situation in northeastern Africa, to advance so fast that they left far behind their Stone Age contemporaries all around the Mediterranean. This is shown at once in the quality of their stone implements, which had during this interval reached what we may call the Neolithic stage. The successive earlier stages represented by the flint artifacts at first left on the plateau and afterward on or embedded in the river terraces, while they were probably earlier than the Paleolithic implements of Europe, roughly correspond



FIG. 20. THREE STAGES OF FLINT IMPLEMENTS FROM NORTHEAST AFRICA. The two below at right from the plateau; all three below are probably Paleolithic; the "ripple-flaked" knife above is from a pre-dynastic burial.

genetically to a Paleolithic stage of work (see lower artifacts in Fig. 20). The progress in the gap preceding the earliest cemeteries carried the Nile-dwellers forward to a Neolithic stage represented even in the earliest burials by superb "ripple-flaked" knives (see Figs. 20, 21). Nothing illustrates the superiority of the prehistoric Egyptian over all his contemporaries in other lands more conclusively than the remarkable precision, beauty and regularity of these flint knives. Nowhere in the world, indeed, have Neolithic craftsmen ever produced anything which can be compared with this work. This advance of Egypt demonstrates an industrial superiority over Europe and Asia beginning in the middle of the fifth millennium B.C., which was maintained some four thousand years and was never lost until the advance of Greek industry and commerce in the sixth century B.C.

The other leading craft possessed by these men of the earliest cemeteries was that of making pottery (Fig. 22), as we

might expect in view of the fact that their ancestors of the lower alluvium were already producing it. It contained a large proportion of Nile mud, and with its black-topped, red polished forms, or red polished with white line decoration and brown or black incised, this earliest cemetery ware is now well known.

It is impossible to offer here a complete inventory of the content of these earliest known burials in the Nile valley, but we may notice the presence of hand-bored stone vessels, face-paint palettes made of slate, and often bearing traces of the face-paint once ground upon them; besides many objects of ivory, like "figures, combs, hair pins, bracelets, rings, vessels, harpoons, etc."¹⁵

The people who thus equipped their dead lived in small settlements along the margin of the alluvium; for the presence of the cemetery of course means that a community of living people dwelt not far away in the cultivated area. A group of wattle huts furnished their dwellings, and around these stretched fields of barley, millet and wheat, with patches of flax, while grazing near were flocks of sheep and goats, and herds of long-horned cattle. Donkeys were already bearing the peasant's burdens from field to village, or village to market. The

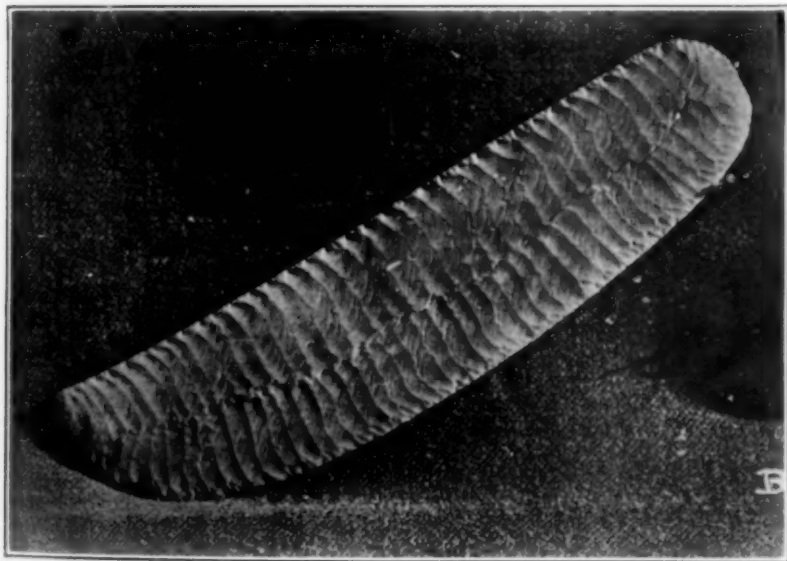


FIG. 21. FLINT KNIFE, RIPLE-FLAKED ON ONE SIDE AND GROUND ON THE OTHER. From a burial in the pre-historic cemetery of Abadlyeh, Egypt. (Photograph by Petrie.)

¹⁵ Reisner, "Archæological Survey of Nubia," Vol. I., p. 316.

great jungles and marshes which once stretched far along the valley, the home of the tropical beasts so long pursued by the plateau hunters and the men of the river terraces, had now been reclaimed and drained and made fit for cultivation of vegetable foods, or the pasturage of flocks and herds. A vast northeast African game preserve had thus been transformed from a jungle into the fertile home of the earliest cultivators of the soil



FIG. 22. POTTERY IN AN EARLY PREDYNASTIC BURIAL OF EGYPT. (After photograph by Reisner.)

and breeders of cattle and sheep anywhere known on earth. The settlements of these earliest agriculturists and cattlebreeders stretched far along the valley from lower Nubia¹⁶ to the sea, and now these vanished generations, who originated animal husbandry and domesticated our food-grains still sleep in these cemeteries, scattered along the margin of the alluvium. Their villages have disappeared, but these cemeteries, discovered only twenty-five years ago, are great repositories of the life which once went on in the vanished settlements.

The character of the food supply is revealed by an examination of the bodies from these cemeteries. The stomachs and alimentary tracts of practically all such bodies from the very earliest cemeteries contain husks of barley, while about ten per cent. also contain millet (*Panicum colonum*) of a species no longer cultivated. The husks of barley are much more difficult to detach from the kernel than those of wheat or emmer, the other prehistoric cultivated grains, and these latter, though they did not carry their husks with them into the bread, may also have been present in the bodies examined,¹⁷ but do not happen to be represented by husks.

Emmer is a kind of split wheat (*Triticum dicoccum*), now very little cultivated. The wild form called by Koernicke and

¹⁶ Reisner, "Archæological Survey of Nubia," Vol. I.

¹⁷ See remarks of Netolitzky, to whom these researches were entrusted by Elliot Smith, in Hrozny, "Getreide," p. 178.

Aaronsohn *Triticum dicoccum dicoccoides* (better by Cook, *T. hermonis*), was discovered by Aaronsohn in 1906 on and around Mt. Hermon in north Palestine, and later as far south as Moab in the trans-Jordan country. In 1910 it was also discovered in western Persia on the Kermanshah road in the Zagros Mountains. There is no doubt, according to Koernicke, that we must recognize in wild emmer the ancestor of cultivated wheat. The



FIG. 23. BODY OF A WOMAN FROM A PREDYNASTIC BURIAL IN EGYPT. In the Field Museum of Natural History, Chicago.

cultivated form of emmer differs but slightly from the wild variety, and the development of our common varieties of wheat (*T. vulgare*, *turgidum*, etc.) must have consumed a long period of time, and required persistent practise of selection. Nevertheless, domestic wheat, with its long career of selective cultivation behind it, already appears in these earliest Egyptian communities, along with the little altered cultivated emmer.

It is interesting to notice that wild emmer is always found growing together with wild barley (*Hordeum spontaneum*), which is common in western Asia. The two were without doubt used together as food by early man, while they were still in a wild state, and domesticated together. Whether all this was done in western Asia or northeastern Africa can be determined with certainty, if ever, only when the botanical exploration of the Near East, at present hardly begun, shall have been thoroughly completed.

It should be noted that the grain found in the bodies of the prehistoric Egyptians and in the pottery jars accompanying them, dating back of 4000 B.C., is the oldest cultivated grain known to us, by over a thousand years. The nummulitic limestone crevices in which Aaronsohn found wild emmer growing in Palestine, are of course plentiful along the Nile, for such stone forms much of the material out of which the Nile terraces were built up. Here then, after using the wild barley and emmer seeds as food for ages, these early Nile dwellers may have begun to plant and cultivate them. It is only after ages of selective cultivation, as shown by the wheat, that the situation is revealed to us in these oldest cemeteries of the world. The long process of selective cultivation which had produced wheat before 4000 B.C., might therefore carry us back of 5000 B.C. for the beginning of the cultivation of grain, and the rise of agriculture.

It is also important to notice that such bodies as Fig. 23 often lie on a reed mat, with flaxen cord, and that some of them are wrapped in linen already displaying a good deal of textile skill. This is the oldest linen known to us, by an enormous margin. The fields of flax which furnished this linen represent a flax culture already very old, and descended probably from a time when the Nile dwellers originated the cultivation of flax.

(To be continued.)

MAN AND HIS NERVOUS SYSTEM IN THE WAR BEING SOME REFLECTIONS UPON THE RELATION OF AN ORGANISM TO ITS ENVIRONMENT. IV

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THE ONSET OF THE GREAT WAR

The civilized world was startled in August, 1914, by the onslaught of the Teutonic hordes upon the people of Belgium and France. We had heard vague rumors of the gathering of the forces of war, and had heard the distant rattle of the saber at times. Some gifted individuals with a vision of the future had warned us, but we had not heard. We had seen the growth of autocratic power, but we forgot the principles of government worked out by our Anglo-Saxon ancestors, and we failed to appreciate the menace to the world of autocratic power at the head of a nation of millions of docile subjects. History was supposed to be one of the agents which would aid man in his process of muddling through by reminding him of past mistakes and the dangers of some unfortunate past experiences. But we heeded not the lessons of history, or did not know them. Some there were who cared not for history, and some said that the time spent on the study of history in our schools was wasted. In one sense, unfortunately, these latter may have been right, for few saw the approach of the storm before it broke. We were dazzled by the glamor of high organization and efficiency and we counted not the cost which must be paid for them. Like a storm, which, eluding the meteorological service, sweeps in from the sea, the war broke upon most of us without warning. But if we look backward, there are few elements in the present conflict that had not been the cause of uneasiness to statesmen and philosophers in the centuries that went before. Mention has already been made of the change in science, with the shifting from the basis of science for its own sake to the basis of work for practical ends. Some of us before the war noted the decadence in freshness and originality in the scientific thought of Germany, and were inclined to place its beginnings in the last decade of the nineteenth century. The extravagance of the imperialistic spirit, and the growing intimacy of the ruler and

the leading deity were made plain to the world in general. All these things had been noticed in Egypt and Babylon, and in both empires, they presaged disaster. The reaction of free peoples to the attempt to force such conditions upon the civilized world was similar to the reactions exhibited by other free peoples in other centuries when similar attempts were made to force such conditions on them. Man's internal organization shapes his behavior, and changes in internal organization come about only as the result of processes of evolution, most of which require great periods of time for their completion. Only in those countries whose peoples were decadent, or whose internal organization was such that individuality was not a matter of great importance, has the proper reaction failed to appear. But, although the combination of Teutonic ruler and leading deity loudly proclaimed the decadence of the peoples of the earth, such decadence either did not exist, or was confined to Germany. Judging from the lack of originality in Germany, individuality, aside from that manifested by the ruling combination, is not a matter of great consequence, and one would really look for a certain form of decadence there. The usual reaction occurred, and the Teutonic hordes were driven back.

But if we outside of Germany had not learned the lessons of the past, we were no worse than the denizens of Unter den Linden or Wilhelmstrasse, for assuredly they had not learned either. The Bourbon kings are not the only ones who "learned nothing and forgot nothing." The Hohenzollerns had not learned that virile races resent attempts on the part of the ruler and leading deity of an enemy country to suppress the expression of their individuality. They had not forgotten the traditions of the Egyptian and Babylonian kings. Their failure, either to learn or to forget, has brought disaster to them as well as to us, and we most unselfishly hope that theirs will be the greater disaster.

THE CHANGE IN GERMAN IDEALS

Strangely enough, one of the most beautiful expressions of the biological ideal of life as I see it comes from the nation in which, in the immediate past, the world has witnessed a recrudescence of monarchical absolutism as rigid as that of Assyria or Babylonia. As Goethe stated it:

Wie das Gestirne,
Ohne Hast, ohne Rast,
Drehe sich jeder
Um die Eigene Last.

But in Germany of the last decade there were few indeed who could draw each one toward his own goal. The recent ruling house of Prussia whose ancestors five hundred years ago were in "Hide and Hair" (perhaps because of his myopia Treitschke was unable to see the cloven hoof, or because of his deafness was unable to hear the clatter) had not only arrogated to itself the privilege of regulating the destinies of all individuals in the German Empire, but had also expressed the desire to extend the same beneficent protection to the individuals of the world in general. But the world in general has long assumed this to be the prerogative of a Being of much greater historical antiquity and, as we have been wont to believe, vastly greater ability than any member of the Prussian ruling house who has yet appeared. To meet this objection, the Kaiser has announced that the welfare of the world has been expressly delegated to his care while his immediate superior is looking after the rest of the universe. To some of us, the credentials which the Kaiser presented are in the same class with other German state documents—mere scraps of paper. There is one point on which the Kaiser may claim a biblical resemblance,—*"I came not to send peace upon earth but a sword."* One point of resemblance is not, however, sufficient to establish the identity of the species of two individuals, and few other points of resemblance occur to me at this moment. But granting all that even the most charitably inclined person could grant, that the Kaiser is not a sufficiently competent systematist to be sure of his identification, and that this delegation of power really comes from the German tribal deity, I still confess to lingering doubt whether the Kaiser is strictly correct in his idea of the geographical location of the dwelling place of this tribal deity. To my mind the geographical range assigned is incorrect, for it partakes much less of the nature of a creature of light than a being of darkness.

The mistake of the German war lords is as patent to the biologist as to the politician or the statesman. If I interpret the course of organic evolution correctly, it has made of man's brain, and through it his mind, a force of nature. There have been occasional lightning flashes of genius in the course of history, and some cataclysms in the form of revolutions, but, on the whole, its action has been more like that of other forces of nature which first cut deep valleys in a newly elevated tableland, then widen the valleys, disintegrate the rocks and reduce them to fine particles, and transport them to other regions until only the hills remain. Finally the hills are leveled and the

genial plain is open to view. So, century after century, man has been making assaults upon the strongholds of absolutism until, in all the civilized world, there is now, let us hope, not one flagrant remnant. The holders of the castle would come forth to dominate the earth, but their vision of a subjugated earth is not to be realized. Not even their shining swords could cope with a force of nature, but fools that they were, they knew not what they would do.

THE PROBLEMS OF THE POST-BELLUM PERIOD

The problems arising out of the war are not settled by the mere cessation of hostilities. The problems of reconstruction demand solution, and upon the wisdom of their solution hangs the destiny of millions of people for years to come. Some comments on these may be permissible here.

I have written of the struggle of man against conventions which repressed the expression of his individuality. Perhaps some may infer that I would do away with all restraint, but against such an inference I would utter a protest. There are good biological reasons why all restraint should not be removed, and one might argue that certain other forms of restraint should be added. In fact, I believe that some additional restraint may be placed upon some tendencies in human nature.

The effort of the Kaiser and the war lords of Germany to impose their will upon others may be regarded as a form of behavior shaped by their internal organization, and, hence, as an effort to express their particular type of individuality. That such efforts should be restrained, few outside of the Teutonic empires or not of Teutonic ancestry will doubt. The war was the immediate effort to restrain such tendencies, but wars do not last forever, and the duration as well as the security of peace will depend upon what means of restraint is adopted after the war. A change in internal organization might be one solution of the difficulty, but I am not sanguine that this can be effected. The student of animal nutrition, regarding the animal as a chemical mechanism, recognizes that, from the dietary point of view, "the internal organization of an animal is not accessible to improvement."¹⁰ Having settled this point, he must do the best he can with whatever foodstuffs may be available. Although, as I have emphasized in these pages, the organization of the higher portions of man's nervous system is not as rigid as that of the chemical mechanisms of the body, I

¹⁰ Armsby, "The Conservation of Food Energy," Philadelphia, 1918, p. 26.

still think it the part of wisdom not to assume that any great changes in reaction will occur, but to assume that, because of an internal organization which one can not greatly change, the reactions will not tend to change greatly.¹¹

Having made such an assumption, we should select such remedies as will best suit the conditions. Anglo-Saxon races in general have tried to permit the manifestation of individuality on the part of the citizens of the state by limiting on the one hand, the power of the state to interfere, and on the other hand, providing lawful means of restraint for such persons as failed to recognize or to heed the restraints imposed by reason. There is no known way of preventing a ruler from becoming mad, but ways may be devised for preventing him from exerting unlimited and unchecked power during his madness. When a whole race becomes mad, forcible restraint becomes necessary, but, if left to itself, there is little chance that a whole race will ever become mad. But if the race is to be trusted, the power of a mad ruler to sway them must be curbed. One mad individual can do but infinitesimal harm alone compared to the harm he may do when he retains unchecked control of a whole people in his madness. But happily the effort of the War Lord of Potsdam to impose his own kind of convention upon the peoples of the world has turned out to be simply another illustration of the vanity of human ambition.

Despite the comments of philosophers on the vanity of human ambition, there is little fear, or hope, that it will fail among the children of men. And the prudent children of men will seek ways whereby the ambitious one may be prevented from injuring his fellows. The establishment of democratic forms of government has done much to remove the menace of political and military ambition, but other forms of civil ambition have grown up since the days of the Magna Charta, the control of which has not yet been satisfactorily worked out. It would seem to a mere civilian that the same principles which led our Anglo-Saxon ancestors to limit the power of one man

¹¹ If the conviction expressed in the text be well founded, then, broadly speaking, *as his neurones are, so the man is*. In this sense Goethe's words, in the mouth of Mephistopheles, can be made to bear a new and almost prophetic significance:

Du bist am Ende—was Du bist.

Setz Dir Perrücken auf Millionen Locken,

Setz Deinen Fuss auf ellenhohe Socken,

Du bleibst doch immer, was Du bist.

Barker, L. F., "The Nervous System and Its Constituent Neurones," p. 221, New York, 1899.

or small group of men in a political way might be extended to all other forms of human activity.

As a biologist, I would emphasize the vast possibilities for evil of a trained or highly organized group of men in the higher stages of society. Without organization and propaganda, ideas make their way but slowly, and only after long discussion. The glamor of organization and efficiency have appealed to us strongly, and we have allowed the formation of great and powerful organizations which are in control of machinery for extensive and widespread propaganda. Many of them have the avowed intention of forcing their own particular types of convention upon great numbers of people. Many of them have expressed the best intentions and have done no great harm as yet. Others have already shown evidences of sinister designs. Many were patterned after similar organizations with strong centralized power. It will be well for us if we recognize these possibilities early rather than late.

The German idea has permeated our universities more than some of us would wish. German universities became a part of the machinery for imperialistic propaganda, and a grateful government has, in turn, established machinery for propaganda for the use of the universities. We have been so harangued and shrieked at by German men of science that, without machinery for propaganda, ideas originating in other countries or ideas opposed to those made in Germany had small chance of meeting with the calm, dispassionate consideration which scientific questions demand, and without which opinion in science becomes but little more than a mere manifestation of mob psychology. Prussian ways of getting professorships, Prussian methods of control once the professorship is obtained, and the will to power rather than disinterested scholarship and service, while by no means universal or universally commended, have been too frequent in American universities to conduce to perfect equanimity on the part of those who believe in democratic principles of merit and justice. It was with these things in mind that a friend expressed in 1914 the hope that one result of the war would be that our universities would become less Prussianized.

Teutonic influence has extended still farther into academic affairs in America. Impressed by the 42-centimeter Busy Berthas and the potency of poisonous gases in warfare, which have been the fruits of the application of German science to the practical affairs of life, there has been much agitation in university and some other educational circles for the extension of

practical education and the restriction or suppression of other forms of academic activity. Practical knowledge is necessary for some of the practical affairs of life, and no one would deny its value. But the argument that we must do certain things because they have been done in Germany leads one to inquire whether the results will be the same here as in Germany. Until some assurance is forthcoming on this point, I am not willing to sacrifice any or all independent opinion of my own merely for the sake of imitating Germany. And I would like further assurance that study of a non-practical sort is without value to the world in general. One might go even farther than this and ask for assurance that work of a non-practical nature is actually harmful to the world. For the scholar works out those things which express his own individuality, and the attempt to restrict such a means of expression is similar in its nature to other attempts to impose restraint upon individuality by setting up an arbitrary convention.

We have forgotten, however, some other things in Germany when we focus our attention upon merely practical matters of their educational system. Art has flourished in Germany in times past and their galleries have been enriched by fair means or foul by great works from other countries. Long ago Huxley called attention to some of the defects of a purely "practical education" and it may be well to recall his words now, for I believe that they are worthy of serious consideration to-day.

The mental power which will be of most importance in your daily life will be the power of seeing things as they are without regard to authority; and of drawing accurate general conclusions from particular facts. But at school and at college you shall know of no source of truth but authority; not exercise your reasoning faculty upon anything but deduction from that which is laid down by authority.

You will have to weary your soul with work, and many a time eat your bread in sorrow and in bitterness, and you shall not have learned to take refuge in the great source of pleasure without alloy, the serene resting place for worn human nature—the world of art.

Practical matters or science or applied science have engaged men's attention in the days of the war, and there are some, even many, who fear that the scholar who works not toward practical ends alone will disappear in the process of reconstruction after the war. But idealism has survived in the world too long to disappear now. For if, by any mischance, the scholar should be driven from our universities and be supplanted by merely practical men, somewhere in the world he will find refuge. We may, in the last extremity, go part way back to the conditions of the scholar in Paris in the fifteenth century as Victor Hugo describes them:

The Ville contained the Halles, the City the Hotel Dieu, and the University the Pre aux Clercs. For offences committed by the students on the left bank (of the Seine), in their pre aux Clercs, they were tried at the Palace of Justice in the Island, and punished on the right bank at Montfaucon, unless the rector, finding the University strong and the king weak, chose to interfere; for it was the privilege of the scholars to be hanged in their own quarters.¹²

There is small hope that all his former privileges will be restored in their entirety unless liberal legislatures amend the charters of our universities so as to allow the erection of their own gallows, but somewhere or somehow the scholar will claim and receive some of his ancient privileges even among the practical men of the day. Perhaps those universities which have established schools of electrical engineering might substitute the electric chair for the ancient gibbet. Garrets may again come into style, and hermitages in the forest may again shelter him from the elements, but the scholar will and must work. But the value of idealism for the world is not yet passed. Surely it is safer for the world that the pale student should spend his time in deciphering the tattered fragments of a Greek palimpsest than that he spend his time in devising a new poison wherewith to slay his fellow man. It is safer for the world that an astronomer should spend his time calculating the motions of a distant sun than that he should calculate the path of a projectile that will kill women in a church seventy miles away. It is better that a man lose his life in vain searching for the pole than that he save it in dreaming of "Weltmacht oder Niedergang," unless he achieves Niedergang. It is better for the world that our children should see great works of art, or great collections in museums than that they grow up on a diet of blood and iron. It is better that one should penetrate to the nethermost parts of the earth and brave the danger of beasts of prey or disease-bearing insects than that he should dream of feats of arms in a war of conquest. For high enterprise and romance are not dead in the world and the history of science itself is "the history of an adventure." But the scholar sets not out on his adventure deliberately to slay.

While the idealist may dream of the day when restraint shall no longer be necessary among the children of men, those who pay attention to the facts of biology must recognize that restraint is still necessary. It is not within the province of the biologist to impose this restraint. That task falls to the law-maker, with whom the biologist has seldom maintained intimate

¹² "Notre Dame," Book III., Chap. II.

personal relations. Yet the problem of the lawmaker and the problem of the biologist have some elements in common.

The methods of science and of law have certain elements in common, although attention is usually focused on their differences rather than on their resemblance. The practise of law consists in the application by deductive reasoning of the principles of law to particular cases. The actual practise of science lies more in the accumulation of facts from which we may one day arrive at a general principle through a process of induction. Yet law must have its inductive side, for the great jurists of the world have built up its principles, which lesser men may apply. And when the great scientist has built up his induction from the facts accumulated by many lesser men, application to particular cases by deductive reasoning is a legitimate method of science (Thomas Case). The man of science has sometimes commented on the waste of human energy resulting from the obscurity of some of the forms of law and the technicalities of its administration.¹³ But just as the man of science recognizes the difficulty of arriving at a clear, definite and unequivocal statement of an induction from the facts at his disposal, so the clear-minded man of law recognizes the difficulty of making a clear, definite and unequivocal statement of a legal principle. But the man of science recognizes that the inductions of science must be revised from time to time, or even wholly rejected, as the number of facts increases and their relationships are more carefully studied. The man of law sometimes insists on the retention of his venerable forms and attempts to fit all modern conditions to an old generalization. The body of law is apt to become a rigid convention and, although the motives of its founders were without reproach, to become an impediment to progress. I have called attention elsewhere to the fact that previous attempts to settle international disputes in accordance with the terms of existing convention have not been wholly successful in avoiding subsequent disagreements or in preventing later wars.¹⁴

The peace conference which is to meet to settle the late war will be faced with the task of arriving at certain principles for the guidance of nations. Those principles, whatever they may be, must be arrived at by a process of inductive reasoning. For the peace and security of future generations, let us hope that the final decision of this conference will be in accordance with the facts as they are known to-day, and that the attempts

¹³ Bagehot, "Physics and Politics."

¹⁴ Pike, *The New York Times*, 1917.

to impose restraint upon generations to come by the retention of outworn and biologically vicious convention will fail. For unless coming generations are decadent, they will refuse to be bound by arbitrary convention and the struggle will break out anew.

The view that individuality is a product of a result of evolution which I have arrived at is not particularly new. But it needs to be kept before us. Bergson's statement has already been quoted. It seems worth while to give here a statement by an American psychologist and philosopher with a more distinct political bearing:

The practical consequence of such a philosophy (*i. e.*, the philosophy of looking for the significant things in the lives of others), is the well-known democratic respect for the sacredness of individuality, is, at any rate, the outward tolerance of whatever is not itself intolerant.

These phrases are so familiar that they sound now rather dead in our ears. Once they had a passionate inner meaning. Such a passionate inner meaning they may easily acquire again if the pretensions of our nation to inflict its own inner ideals and institutions *vi et armis* upon Orientals should meet with a resistance as obdurate as so far it has been gallant and spirited. Religiously and philosophically, our ancient doctrine of live and let live may prove to have a far deeper meaning than our people seem to imagine it to possess.¹⁵

In the interest of stability of our American institutions, it is to be hoped that the attempt of a European nation to inflict its own inner ideals and institutions *vi et armis* upon other nations and ourselves may act quite as effectively as James hoped the resistance of the Orientals to our own attempts would in imparting a passionate inner meaning to the phrases that sounded so dead five years ago. Let us hope also that the deeper meaning of our ancient doctrine of live and let live may come to us without further unhappy experience. For, as I believe, certain forms of propaganda in our country are not far removed in spirit from militarism, and neither is far from intolerance.

As for our failure to appreciate the teaching of history, another sentence of James is pertinent here: "The changing conditions of history touch only the surface of the show."¹⁶

History to most of us is a matter of the distance receptors alone, and may have no significance for us. It is only when things touch us more closely, when they become matters of the contact receptors, the proprioceptors and the interoceptors that they have real significance to us and awaken a real human in-

¹⁵ James, William, from the preface to "Talks to Teachers and Students," New York, 1900.

¹⁶ *Ibid.*, p. 300.

terest. The Egyptians and Babylonians were too far away for anything but the distance receptors to reach them, and we did not translate our impressions from sight and hearing into the terms of impressions from other sense organs. The present war should have touched us deeply enough, and should have made sufficient appeal to those receptors which apprise us of pain and sweat and hunger to give history a real meaning among us for generations to come.

History, from one point of view, has a distinct interest to the biologist. The intrigues of rulers and the salacious details of the private life of court personages does not necessarily impress him. But the reaction of a people to any given set of social or political conditions may have a more intimate relation to the work of the naturalist. For just as the testimony of the rocks, the paleontological history of animals, shows what course the evolution of form has followed in the race, so we may regard the record of history as showing what man has done under a given set of conditions which, in more ways than one, bear a resemblance to some of the experimental conditions which we sometimes impose in order to study the behavior or reactions of animals.

A quarter of a century before James wrote, the memory of the events of our Civil War was still vivid enough to lend significance to the facts of history. To quote again from Lowell:

They steered by stars the elder shipmen knew,
And laid their courses where the currents draw
Of ancient wisdom channeled deep in law,
The undaunted few
Who changed the Old World for the New,
And more devoutly prized
Than all perfection theorized
The more imperfect that had roots and grew.

If in so short a span as one generation we shall again forget the stars the elder shipmen knew, and in the space of half a century be again involved in a struggle for our existence as free men, let us hope that we will not fail. Wars will probably not cease because attempts at aggression will end, but if wars do cease, it will more likely be because we learn to recognize early the signs of danger, and deal with the agents of evil before they become too powerful to be controlled. Before we become able to do this as a nation, we must recognize the value of "The more imperfect thing that had roots and grew" as compared with the schemes for universal salvation that are being so generously set before us in these later days. We may

vaguely wonder whether the doctrine of "America über Alles," unashamed and unrebuked, will be wholly an influence for good.

I have attempted to show that the Prussian government of to-day has in it much of the elements of the old tribal theocracies. I have attempted to show also that man's mind which, if I am right, is a product of his evolution, rebels against any such scheme of government. To the biologist such a system is merely the recrudescence or the persistence of superstition. I have attempted to point out also some of the dangers of such a scheme. But these dangers have been so well summed up and so trenchantly expressed by a philosopher that I quote them in closing. Few in his day appreciated their significance, and many and bitter were the attacks upon the author at the time, but the application to the Prussia of the past two decades seems clear. To those who would save such a system as the Prussian autocracy the words may be particularly dedicated: "That which you keep in your hearts, my brothers, is the slender remnant of a system which has made its red mark on history, and still lives to threaten mankind. The grotesque forms of its intellectual belief have survived the discredit of its moral teaching. Of this what the kings could bear with, the nations have cut down; and what the nations left, the right heart of man by man revolts against day by day. You have stretched out your hands to save the dregs of the sifted sediment of a residuum. Take heed lest you have given soil and shelter to the seed of that awful plague which has destroyed two civilizations and but barely failed to slay such promise of good as is now struggling to live among men."¹⁷

¹⁷ W. Kingdon Clifford, "The Unseen Universe," London, 1879.

APPLIED NUTRITION FOR RAISING THE STANDARD OF CHILD VITALITY

By Professor I. NEWTON KUGELMASS

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WHILE approaching the brink of the dawn of a world cataclysm that catalyzed evolutionary progress in both humane and inhumane activities, let us take inventory of a phase fundamental in world domism—the “reconstruction” problem of child welfare.

The war has sobered us and its lessons must be taken truly to heart for our sufferings were our instructors, Pathemata Mathemata. Of the doctrines reaped, two point for our consideration—(1) the necessity for physical and mental efficiency in every citizen and (2) the menace of the dearth of youth.

Ours is the great obligation to build the rising generation an optimum in body, mind and character if we are to carry into the future the strength and steadfastness which mark the present. Sentiment and emotion alone eventually fade into oblivion—the deadly policy of *laissez faire*, *laissez passer*. They must be translated into practical terms of concentrated effort and endeavor; now is the time. Let nothing mar nor hinder, not even the blood-coagulating dollar. The time is here, the place is everywhere and the obligation every one's to serve in the cause of national upbuilding through child welfare, for the child is the embryo of the nation's progress, the parent of the future generation, the potential citizen.

THE ANTECEDENT FACTORS OF THE RESULTING CHILD

The caliber of the child may be expressed as the resultant of the two “moments,” heredity, the intrinsic organization of the germ cells and environment, the extrinsic, stimulating, inhibiting or modifying influences. Evidently to attain the ideal child



FIG. 1.

these two causative factors must be ideal. Modern applied scientific tendencies have been in the direction of "patching-up" the child rather than in the more important or at least as important fields of heredity and environment perfection. There is nothing against these tendencies except that they are unbalanced. To raise the health standard of the average child we need science in the service of alleviating the ill-causes much more so than remedying the ill-effects.

Let us throw the balance in the other—the more serviceable direction. Curing superficial symptoms of woeful causative inadequacies has never and will never relieve the situation. We need to face and cure both evils equally to serve as we should and as we can with intelligent application of our available knowledge. The application of the sciences on child welfare



FIG. 2.

have thus far been delinquent and the more that "one-sidedness" is practised the longer the prolongation of our low heredity status to our own detriment and that of the coming generations upon which the nation's future depends. Of the two causative factors in child molding—heredity and environment—the latter promises far more effective returns per unit effort, but both are in dire need of attention.

For our immediate purpose let us consider environment and its component influences of which the home and the school are the most permeating. The salvation of the child lies in the complete harmony of school and home functioning with the body developments of the child with age.

CHILDHOOD IN CONSTANT FLUX AND REFLUX

An analysis of body developments with age shows the child not a miniature man, but distinctly different from the adult in vitality, intellect, emotion, instinct and metabolism. As a matter of fact, these intrinsic differences are characterized throughout childhood by their constant alternation in activity and passivity. Child metamorphosis proceeds with constant flux and reflux—a living illustration of Newton's Third Law of Motion: "Action = Reaction."

PERIODICITY OF ACTION AND REACTION IN HUMAN METAMORPHOSIS

Age	Growth	Coordination	Development	Characteristics			
				Endo-thermic	Recep-tivity	Stimu-lation	Exalta-tion
Birth to 7	Rapid	Motor	Corporeal	Endo-thermic	Recep-tivity	Stimu-lation	Exalta-tion
7-14	Slow	Motion and emotion	Intellec-tual	Exo-thermic	Produc-tivity	Fatigue	Depres-sion
14-17	Sudden		Corporeal	Endo-thermic	Recep-tivity	Stimu-lation	Exalta-tion
18-25	Slow	Emotions and ideals	Intellec-tual	Exo-thermic	Produc-tivity	Fatigue	Depres-sion

THE RELATIONS OF SCHOOL LIFE TO THE CRITICAL TRANSITION EPOCHS IN CHILD DEVELOPMENT

In the light of the above analysis of human metamorphosis the school's responsibility in molding childhood in harmony with its fluxating development is evident. Thanks to the world educators and psychologists for stimulating research in the cause, but as yet our school systems are far from what they should and could be.

The effects of school life upon the child are appalling. Extensive surveys throughout the country have shown persistent prevalence among school children of: (1) growth retardation, (2) appetite deterioration, (3) corpuscle degeneration, (4) blood deoxygenation, (5) metabolic alterations, (6) superficial respiration, (7) morbidity, (8) malnutrition, (9) remediable defects, (10) reduced vitality. Is the school functioning harmoniously with the development periods of the child? Is the home guilty of negligent depreciation of vitality through inadequate nurture, health conditions and care? Yes, the school and the home are the reciprocally responsible sources.

The scope of the educational machinery is still narrow if its aims are not generally all-inclusive and well-balanced, if its habitual training for healthy physique is not on par with the mental. The great problem at our advanced stage is to get away from an education for a living to an education for a life to best enable and set free each individual to do his and her best for the common welfare. Upon that necessary and sufficient transition in educational ideals pends the safeguarding, up-building and perpetuating of our American democracy.

Then too the "rule-of-thumb" empiricism for bringing up children is incompatible with their variant needs. Deficiencies heaping up thereby as a result of neglect and ignorance among poor and rich alike rob humanity of latent productivity—a great impediment upon our nation, an irretrievable waste of our rising generation. The scientific and rational principles of health and nutrition must become more assimilated into the con-

ceptions and practises of the public or even the medical profession if we are to build a maximum efficient democracy.

APPLIED NUTRITION FOR RAISING THE STANDARD OF CHILD VITALITY

With the vast number of variegated food materials, natural and artificial, palatable and adulterated, drugged and normal all behind attractive camouflaged labels it behooves one to select what will constitute an adequate diet for the growing child. Faulty diets have been devitalizing the innocent child with resultant deficiency diseases. Malnutrition has impoverished the child world with reduced vitality, disease susceptibility, minimized educational receptivity, anæmified physique and resultant stunting of mental and physical development—basic elements for mollycoddles not men, wishbones not backbones, jelly-fish not brains. The retribution for dietetic sins in childhood is a much more speedy reaction than in adult age. Stop the starving, stunting, stultifying of the child. It's criminal. Every child has a biologic birthright to a useful body and mind. Grant that right by complying with natural laws governing body needs formulated by science. The science of nutrition is at our service.

Instinct a Non-reliable Guide in Food-selection.—The perpetuity of change in the human species modifies simultaneously the dependent factors on health preservation as a result of the curtailment of the activities of various parts of the body so that claiming practicability of instinct as a natural guide on the basis of past service to humanity is irrelevant. Furthermore, instinct varies with personal idiosyncrasy, habits, conventions, moods—conditions not necessarily compatible with food value to the body. Reliable knowledge should be if it is not at the command of all to supplant inherited instincts.

FROM BIRTH

(Relative in proportion to body weight)

Increase	Decrease
1. Density of blood.	1. Water in blood.
2. Concentrated red corpuscles.	2. Concentrated white corpuscles.
3. Concentrated haemoglobin.	3. Iron content.
4. Mineral matter.	4. Organic Matter.
5. Calcium carbonate.	5. Calcium phosphate.
6. Oxygen absorption.	6. Thyroid gland, kidneys, thymus.
7. CO ₂ excretion.	7. Suprarenal capsules.
8. Colloidal substances.	
9. Brain, heart, lungs.	
10. Metabolic intensity.	

The Child Needs (1) tissue foods, (2) energy foods, (3) regulating foods, (4) protective foods. Nutritional instruction should be on the basis of food function rather than composition of interest to the chemist only since the former appeals to the pupil's actual experience and familiarity while the latter rarely strikes "home."

The general factors interrelated with child nutrition are a knowledge of (1) food functions in body, (2) essential body component sources in foods, (3) relative amounts of food required per age, (4) adaptable foods to the digestive system, rate of growth, state of development, (5) feeding intervals per age, (6) proper sequence at mealtime.

THE TISSUE FOODS

Feeding children involves not only waste repair, the adult need, but new tissue building as well if the child's growth is not to be stunted. The body tissues are: (1) The circulating—blood, (2) the master—brain and nervous system, (3) the contractile—muscles, (4) the supporting—bones and teeth, (5) the cryptorrhetic—thyroid and secretions.

A diet may contain all the necessary constituents for tissue repair and yet may be lacking in some constituents essential for new tissue growth. If these constituents can not be formed in the child organisms as they can in the adult out of others in the diet, it is evident that they must be supplied to the child from without else abide by the fate of inadequate dieting. The animal and vegetable complex proteins upon the action of proteolytic enzymes in the stomach are ultimately hydrolyzed into the digestion products essentially the various amino-acids. These, absorbed into the blood, are the building units of the body tissues to be formed. Since different protein foods contain not all of the amino-acids essential for tissue synthesis and in different proportions, it is very essential that the child get a proper combination of proteins for the body availability of all the amino-acids and their right proportions required for both new tissue building as well as for tissue repair. It is not strictly protein as such, but amino-acids that the body needs. Those indispensable to growth are arginin, cystin, histidin, lisin, and those essential to maintenance or tissue repair are the aromatic amino-acids. Any surplus is partly converted by de-amination into carbohydrate and fat to contribute to the body's energy requirements. In all the child's total protein requirement is more per unit body weight than the adult's. This does not mean, as is the usual misapprehension, that the proportion of proteins to

total food intake is greater. The normal need is protein to be ten per cent. of the total ration for children as well as for adults. The necessary and sufficient protein utilization and assimilation depend on what may be termed the *amino-acid efficiency* of the ingested food. From this standpoint a few foods may be graded as follows: (1) milk, eggs, cheese, meat, fish; (2) wheat, oats, pulses, nuts; (3) corn; (4) gelatin. This does not mean that only those in (1) should be consumed, for the others may have essential components for other body functions. It does point, however, to the necessity for guarding children's diet so that upon digestion the specific kinds and proportions of amino-acids will be available.

In infant feeding the available chemical components of foods are not the only factors, but their physiologic functions must be considered as well. During the nursing period the infant is not adapted for the metabolism of nutrients derived from sources other than woman's milk. Breast feeding develops the digestive tract, functions in better brain and nerve building by the lecithin content in the milk, gives all the amino-acids in the proportions requisite for growth, serves for stronger teeth and is generally correlated with higher mortality. Furthermore, *B. bifidus* is present to the exclusion of other forms in the normal breast-fed child. It produces no putrefaction, decomposes no albuminous matter which would form toxic products. These bacilli are more than harmless, they are an important defense in preventing intestinal putrefaction and displacing harmful flora.

THE ENERGY FOODS

Children's energy requirement is greater per unit surface area of the body than the adult's because of their higher metabolism. *The energy functions* for keeping body temperature normal, for the maintenance of the life processes more rapid than in adult, for muscular activity, for body syntheses of the building materials utilized in repair and growth, and for storage.

The carbohydrates are absorbed into the blood plasma as monosaccharides after intestinal digestion. These upon oxidation liberate energy for the performance of muscular movements as well as for bringing about endothermal reactions. Any surplus is stored in the liver, muscles and other organs as glycogen. Excessive amounts beyond the normal assimilation limit of the organs tend to be transformed into fat.

Fat, the concentrated potential energy source, after being

hydrolyzed in the stomach yields fatty acids and glycerol which are absorbed by the lymph vessels and together taken up by the blood plasma, distributed to the tissues according to their needs, contributing to the constitution of protoplasm as well as for heat production. Any excess aids the conservation of body heat.

Any excess protein intake will be de-aminized, yielding carbohydrates and probably fats for the body's energy requirements. In other words all foods are sources for heat and muscular movements in proportion to body preference, specific nutrient availability and surplus.

In child development the specificity of carbohydrate function is prevalent. Galactose, for instance, is essential for nerve medullation of the cerebrum. It is derived from lactose, the milk sugar and none other will replace it. Again, milk, although containing an insufficiency of the total carbohydrate requirement, has the essential sugars entering into the composition of the child's body. Another favorable point is that lactose in milk is least liable to fermentation, whereas all other sugars yield acid products in the stomach.

Sugar is a beneficial muscle food for the children if taken in diluted form. Excessively large concentrated amounts of sugar ingested irritate the tissue, abnormally increase the mucous secretion as well as the acid gastric juice content, thereby interfering with normal digestion. Furthermore, the requisite vegetable food intake will be diminished since it satisfies the appetite without adequate nourishment with serious consequences of the deficiency diet to growing children.

The four per cent. fat content in milk in the emulsified palatable and easily digested form is the optimum satisfying the caloric need of the normal child. Excessive fat ingestion overtaxes the infant's undeveloped digestive system, causing the prevalent gastrointestinal indigestion with a simultaneous loss of alkalinity which may result in acidosis.

THE REGULATING FOODS.

During the functional activity of the child mineral nutrients are indispensable for all tissue building providing the supporting structures as well as for metabolic regulation. Among the diverse functions of the inorganic components in the body are:

A. As Stimulators—

- a. Conducting nerve impulses.
- b. Activating enzymic transformations.
- c. Increasing metabolic reaction velocity.
- d. Catalyzing cellular activity.

B. As Regulators—

- a. Controlling heart and muscular activity.
- b. Maintaining blood acid-base equilibrium.
- c. Counteracting harmful products by chemical combination.
- d. Governing respiration processes.
- e. Aiding proper membrane permeability.
- f. Providing a solution concentration of normal osmotic pressure.

The prevalence of anemia during the weaning period of the infant is due to iron inadequacy, which causes a diminution in the hemoglobin and chromatin bodies, both largely responsible for metabolic and growth processes. It is imperative that special provision be made in the child's diet for an iron content sufficient for both body maintenance and increasing blood supply, since the iron reserve continually diminishes from birth on. The iron component in the daily ration should not be the sport of chance, but purposeful inclusion if due justice is to be afforded to the child's development. Medicinal inorganic iron in tonics is not only a costly substitute for a healthy dietary violation, but no actual substitute at all since it is temporary acting as a stimulus rather than a hemoglobin producer. You can not beat nature to it, but accept her organic iron in foods combined in assimilable form for the body.

Malnutrition associated with flabbiness, weak bones and teeth are a direct result of phosphorus deficiency. Retarded development, structural weakness and rickets observed in children are effects of calcium inadequacy. The structural supporting tissues partake of the continuous metabolic changes as well as the others. The former need continual replenishment as well as the latter. The child's need in addition to the normal calcium and phosphorus assimilation in all tissues is a sufficiency for the constant structural increase during growth.

Children must have an adequate supply of inorganic components. As a matter of fact maximum duration of life depends on the maintenance of a concentration of salts in the blood proportional to those found in the sea, an experimental fact (Loeb) probably correlated with the marine origin of vertebrates.

Life depreciation is evident if we view the ill-effects of mineral deficiency. Just protein-carbohydrate-fat diet is disastrous. It means an acid laden system without any alkalies from mineral sources for neutralization. Intestinal putrefaction is immensely increased, a condition largely responsible for fifty per cent. of body impairment. Furthermore, interference with the body-regulating and stimulating powers will inevitably result in nervous and muscular disturbances—constipation, acidosis,

scurvy and what not. The familiar grouch is a living example of mineral deficiency in the diet. Keep the child blooming with a positive and ever-pleasant disposition by sufficient mineral salt provision.

In the table below the foods are arranged in the order of diminishing content of the essential mineral constituents per unit weight of fresh food compiled from Professor Sherman's tabulations in his "Chemistry of Food and Nutrition." Iron, phosphorus and calcium are listed because of the liability of inadequate provision in the child's daily ration.

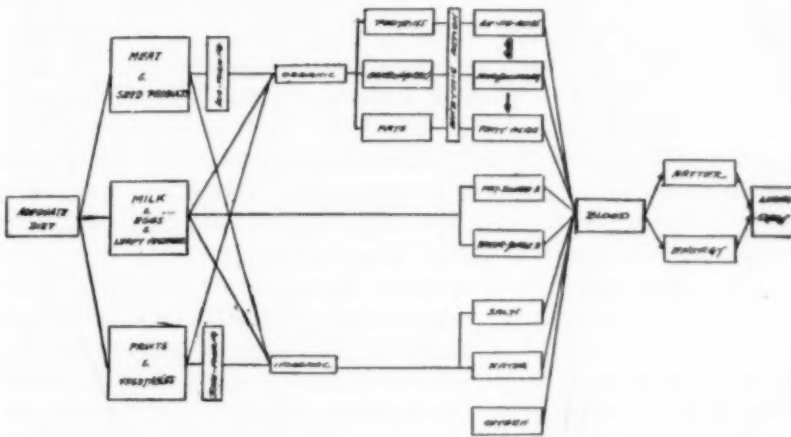


FIG. 3. THE METABOLIC COURSE OF FOODS.

Iron	Phosphorus	Calcium
Beans (lima, dried)	Beans (navy, dried)	Almonds
Beans (navy, dried)	Egg yolk	Beans (dried)
Peas (dried)	Peas (dried)	Egg yolk
Wheat (entire grain)	Peanuts	Milk
Beefsteak (lean)	Wheat (entire grain)	Peas (dried)
Spinach	Oatmeal	Oatmeal
Oatmeal	Almonds	Walnuts
Raisins	Walnuts	Peanuts
Eggs	Beef (lean)	Turnips
Prunes (dried)	Rice (polished)	Parsnips
Beans (string)	Parsnips	Carrots
Corn meal	Potatoes	Oranges
Potatoes	Turnips	Prunes (dried)
Barley flour	Beets	Wheat (entire grain)
Cabbage	Pineapples	Beets
Corn (sweet)	Bananas	Beans (dried)
Rice (polished)	Oranges	
Apples	Apples	
Milk		

WATER AS A REGULATING FOOD

The internal body medium which makes vital processes possible is water. It is the most abundant cell and blood component. Common as it is water is endowed with the most wonderful properties, nature's special provision for its following regulatory functions: (1) maintains normal body temperature, (2) solvent and dispersion medium, (3) accelerates chemical reactions, (4) transfers heat between cells, (5) conveys food and oxygen to the tissues, (6) removes metabolic waste products, (7) coordinates metabolic processes.

The water content of the body is not a function of body weight, but of age. The infant needs four times as much water as the adult per body weight. This indicates that we are gradually "drying out" with seventy per cent. water content in youth diminishing to fifty-eight per cent. in adult age, but for the sake of growth beware "drying" the child, for tissue efficiency varies directly as the water content therein. Furthermore, the body carbohydrates and fats form stable dispersion systems with water—essential criteria for soundness of constitution. Any water deficiency for the child may result in (1) growth disturbances, (2) muscular slackness, (3) gastro-intestinal indigestion, (4) discordant metabolic coordination, (5) fluctuating fever, (6) increasing blood viscosity, (7) increased catabolism. Let the child have plenty of water during and between meals. A glass of water on rising and one on retiring will supplant many a purgative dose.

THE PROTECTIVE FOODS

Biologic studies correlated with chemical have led McCollum and his co-workers to the recently extolled conclusions of profound importance in child nutrition that life perishes without foods containing fat-soluble A and water-soluble B. Faulty diets have been largely responsible for "deficiency diseases," *e. g.*, xerophthalmia, beri-beri, scurvy, pellagra and rickets. Adding these two unidentified substances brings about recovery. Insuring a non-appearance of any of these diseases, or rather making the child immune to them, lies in the ingestion of foods containing these two essential components. They stimulate growth and well-being probably by initiating and coordinating the protoplasmic formation reactions among the essential components prepared by the digestive processes. The more of them the child gets the better it feels.

The protective foods containing them are milk and the leafy vegetables. Here too their relative functioning is of marked gradation. As a matter of fact a nation's status may be interpreted from the standpoint of its utilizing milk or leafy vegetables or both as its protective foods. As McCollum puts it:

Those peoples who have employed the leaf of the plant as their sole protective food are characterized by small stature, relative short span of life, high infant mortality, and by contented adherence to the employment of the simple mechanical inventions of their forefathers. The peoples who have made liberal use of milk as a food, have, in contrast, attained greater size, greater longevity, and have been much more successful in the rearing of their young. They have been more aggressive than the non-milk-using peoples, and have achieved much greater advancement in literature, science and art. They have developed in a higher degree educational and political systems which offer the greatest opportunity for the individual to develop his powers. Such development has a physiological basis and there seems every reason to believe that it is fundamentally related to nutrition.

Just as the sulphuric-acid output is the chemical barometer of a nation, so the amount of milk production is its health barometer. Milk has no duplicate, no substitute. It towers above all other foods. It is nature's best agent for child-building and a national wide provision must be made for its ready access to the growing child if our goal is human personality well grown and ready in body and mind.

THE CHILD'S ADEQUATE DIET

Satisfactory nutrition for optimum child growth and development is attained by diets well-proportioned in the essential foodstuffs with plenty of water.

$\frac{1}{3}$ Milk.	$\frac{1}{3}$ Meat, Eggs, Seed Products.	$\frac{1}{3}$ Fruits, Vegetables and the Leafy Vegetables.
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An additional dietary factor of vital importance, a daily American mispractice is the lack of balance of acid and base forming foods. If the nutrients are present in proportion to the body's requirement the bases will predominate. The foods below are listed in the order of their decreasing resultant acidity or basicity as demonstrated by Professor Sherman of Columbia University.

<i>Acid-Forming</i>	<i>Base-Forming</i>
Egg yolk	Beans (lima, dried)
Fish (haddock)	Beans (dried)
Meat (lean beef)	Raisins
Oatmeal	Celery
Eggs	Cantaloup
Wheat (entire)	Lettuce
Rice	Potatoes
Crackers	Oranges
Egg-white	Lemons
Cereals, meat and fish	Bananas
Acid Elements: Cl, S, P.	Cauliflower
	Cabbage
	Apples
	Milk (cow's)
	Fruit and vegetables
	Basic Elements: Na, K, Ca, Mg

The child's normal diet should consist of sufficient milk, fruits and vegetables to neutralize the acids formed from the other foods. The American custom of acid-forming dessert is largely the cause of her dental troubles at the child's early age. These sweet or starchy foods decompose in the interstices of the teeth with the production of acids which diminish the saliva alkalinity, flow and effectiveness. The acids further act upon the lime salts of the enamel, favor tartar deposition and pus formation in the alveoli, thus giving entrance to microorganisms which destroy the tooth structure. The French dessert principle is correct. It is a base-forming food—fruit. It is wrong for parental customs, conventions and idiosyncrasies to victimize the innocent child.

The quantitative feature as well as the qualitative is of important concern in dietary rationing. Waste of the rising generation is too evident for malnutrition through under nourishment not to be considered. It is well to abide by the child's total food requirement with greater per unit weight and also per unit surface than the adult's. In fulfillment of this requirement it is not necessary to use analytical scales or resort to extensive calculation of a man in full vigor at moderate work; the following fractional parts per age may be used to advantage.

Man	1.0
Woman	0.8
Boys (14-17)	0.8
Girls (14-17)	0.7
Children (10-13)	0.6
Children (6-9)	0.5
Children (2-5)	0.4
Under 2	0.3

RELATIVE TOTAL FOOD REQUIREMENT.

To recapitulate, the child's diet is different from the adult's in some of the following respects: (1) Natural and simple, (2) plenty of milk and leafy vegetables, (3) plenty of water, (4) no stimulants, (5) no highly seasoned foods, (6) hard foods during tooth development, (7) coarse, fibrous foods for smoothening teeth surfaces, (8) heartiest meal at noon, (9) no food between meals, (10) no sweets at the beginning or end of meal.

From the above considerations we realize that body needs are governed by natural laws formulated by science. The closer the adherence and the more intelligent the application of the available knowledge the higher the standard of public health and vitality. Educational reforms will bring the science of nutrition from the theoretical background to the practical front. For that indispensable service we need universal instruction in nutrition, dietetics, prophylaxis, child health; competent trained elementary school teachers and health visitors in nutrition and public health; infant welfare centers; social service staffs; more social-unit organization work under the auspices of the child-welfare leagues and child health associations; public cooperative kitchens; public demonstration centers; public-school child feeding; regular and periodic inspection of school children; more financial aid to mothers; more housekeepers' clubs; more public lectures on health, nutrition and sanitation. The public can not go to the schools; we must go to the public.

COOPERATION AND INDIVIDUALISM IN SCIENTIFIC INVESTIGATION

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THE dominant note in the papers and discussions of the biologists at the Baltimore meeting of the American Association for the Advancement of Science and the affiliated societies,¹ December 23-28, 1918, was the plea for greater cooperation among scientists. There were not wanting, however, those who maintained the need of individualism also, and its importance in scientific work. As a result one well-known botanist apparently expressed the feelings of some others when he said that after listening to the various papers he was left in a state of perplexity in regard to these matters. If such perplexity is at all general, it would seem desirable to try to discover its source and come to some better understanding as to the relation of cooperation and individualism in research.

In this case as in many others in which friends and colleagues fail to agree, the trouble appears to be largely due to a difference in interpretation of terms rather than in any real difference of opinion. Confusion of ideas and conclusions come frequently from lack of agreement as to the meaning of terms.

In discussing this subject, some seem to have taken for granted ideas which have not even been stated. As an academic proposition, most of us will agree that the chief aim of scientific investigation should be to advance knowledge and improve the condition of mankind. In attempting to attain the high ideals which are being proclaimed to-day by the leaders in all fields of human endeavor, we must not forget that if the majority of the

¹ The following are a few of the papers referred to: Livingston, B. E., "Some Responsibilities of Botanical Sciences," *Science*, N.S., 49, 199-207, February 28, 1919. Coulter, J. M., "The Botanical Opportunity," *Science*, N.S., 49, 363-367, April 18, 1919. Ransom, B. H., Osborn, H., "Methods of Securing Better Cooperation Between Government and Laboratory Zoologists in the Solution of Problems of General or National Importance," *Science*, N.S., 50, 27-30, July 11, 1919. Whetzel, H. H., "Cooperation among Plant Pathologists," *Cornell Countryman*, 16, 13, 36, 38, 40, February, 1919; "Democratic Coordination of Scientific Efforts," *Science*, N.S., 50, 51-55, July 18, 1919. Lyman, G. R., "The Unification of American Botany," *Science*, N.S., 49, 339-345, April 11, 1919. Harper, R. A., "Stimulation of Botanical Research After the War" (unpublished).

individuals in any nation or group do not possess these ideals and take a deep personal interest in their attainment, no great progress will be made.

COOPERATION

All are familiar with the ordinary dictionary definition of "cooperation." It is working together for one end or purpose. Cooperation has accomplished much in many fields of human activity. It has been asserted that cooperation won the great war and it undoubtedly was a very important factor. This accomplishment alone would naturally cause the word to appeal to us after having passed through the titanic conflict which has exterminated millions of human beings and is the direct result of the antithesis of cooperation, viz., competition of the basest and most malevolent type.

In cases where the destruction of individuals, families and nations is threatened, many gladly cooperate and work together for the preservation of life and property who would not be willing to forget their petty differences and prejudices and unite their efforts for less striking though equally important purposes in times of peace.

It must be recognized that it is only by organized cooperative effort that many of the great scientific problems now presenting themselves for solution can be successfully attacked. No single human mind can encompass all the knowledge necessary to solve many of the complex problems, which involve a profound knowledge of various branches of science.

Cooperation has been demonstrated to be of great importance in solving many of the problems presented in the present conflicts and activities of the human race. As scientists, we should determine if possible just how this plan can be applied most effectively to the solution of our particular problems. Cooperation in its broadest sense covers of course all interchanges of courtesies and assistance between investigators. If one is investigating an organism or group of organisms and a colleague supplies cultures or material of certain species, this is a simple form of cooperation. On the other hand, it may involve the intimate association of a group of specialists working together for years on some complex problem.

The advancement of science and the solution of its problems depend upon the availability of many materials, instruments and other facilities. Our laboratories, our apparatus, our libraries, our means of publication and illustration, either directly or indirectly are the result of cooperative agencies and activities. The phase of cooperation, however, with which we are most directly concerned at present is that which has been

undertaken in connection with scientific work carried on by individuals, offices, bureaus and institutions, in which investigators or institutions pool their interests, funds and men in attacking some broad problem. In such cases, if the investigators are responsible for carrying out the scientific work involved, they must come to some general understanding in regard to the division of labor, resources and other matters involved. In order to carry out such a project, the participants must be actuated by proper motives and not by selfish aims. Most of us will admit as a general proposition that selfishness is the chief source of our troubles in scientific work as well as in other human relations, but we are somewhat sensitive and hesitate to admit it so readily when the application becomes too personal. Few of us, I fear, however, will be prepared to plead entirely innocent.

It should go without saying that there can be no real or successful cooperation between persons who undertake the work in the spirit of horse traders, the chief aim being to see which can get the best of the bargain. Neither can successful cooperation be inaugurated and carried on by command or direction of those in authority. The cooperation must be voluntary and the problem attacked must be adapted to cooperative effort. Cooperation can not be applied to advantage in all cases and under all conditions. Its applicability and effectiveness must depend upon the particular problem and the individuals involved.

To attain the best results the participants should also be optimists, not pessimists. An excellent criterion has recently been proposed to classify individuals in this respect by determining their attitude toward oysters. The optimist is said to be always looking for pearls and the pessimist for ptomaine poison.

An obstacle to cooperation among organizations and institutions is the more or less artificial divisions of the field of investigation which have been made chiefly for administrative purpose, but which must sometimes be disregarded by mutual consent in order to attack and solve a problem most effectively and quickly. Unfortunately there are sometimes directors of scientific work who lack sufficient understanding of the problems involved to approve and encourage cooperation among the investigators who are naturally fitted for and willing to do such work.

Cooperation in scientific work is not comparable to joining hands in mere manual labor. In such cases we may simply lighten each others burdens or accomplish the task quicker. In cooperating on a scientific problem each worker should con-

tribute something which he is better fitted to perform than any other of the cooperators. The contribution of each differs chiefly in kind or quality instead of quantity.

It may be said that sufficient difficulties have already been mentioned to demonstrate the impracticability, if not the impossibility, of any general or effective cooperation in research. We refuse, however, to take such a pessimistic view of the situation and can not believe that the present generation of scientists is so hopeless. Our faith in the possibility and practicability of cooperation among scientists is not founded entirely upon academic grounds, but upon actual demonstration by experiment.

Many will be able to recall one or more examples of successful cooperation in attacking some scientific problem. To cite a specific case in phytopathology we may refer to the recent investigation of chestnut blight. Mutually agreeable cooperative arrangements were made between different offices in the Department of Agriculture and various experiment station workers to attack different phases of the problem. This cooperation was so broad that it included entomologists as well as physiologists, pathologists, taxonomists and chemists. By this arrangement all the varied aspects of the problem were studied, and much greater and more rapid progress was made in the solution of the whole problem than could have been made by any other plan. Unfortunately, lack of funds prevented carrying certain phases of the work to completion, but this was no fault of the plans or the investigators involved.

The problems in plant pathology being those with which we are most intimately acquainted we may be pardoned for citing an example of work which is typical of many pathological investigations in which cooperation is essential for success. Recently investigations of the cause and prevention of the decay and spoilage of fruit and vegetables in transportation and marketing have been undertaken. It was soon found that much more knowledge of the normal and pathological physiology of such plant products must be obtained. This required the service of specially trained, expert physiologists and biochemists. As many microorganisms were also involved in the decay, expert mycologists and pathologists were needed to solve the problems connected with their life history, relationships and physiological characteristics. Certain practical phases of the work also required the assistance of pomologists, refrigeration and market experts. It would appear self-evident that no one person could do the work necessary to carry such an investigation to a successful conclusion. It might be said that the problem could be separated into its various parts and assigned to physiologists,

biochemists, pathologists, mycologists and various other experts to work out by themselves. Experience has proved that the problem can not be economically or effectively solved in this manner. The various phases form such an intricate, complex problem that it is only by specially trained investigators working in closest cooperation and mutual understanding that the problem can be solved.

The best known general cooperative effort in plant pathology is that undertaken by the War Board of the American Phytopathological Society. In order to bring to bear as effectively and quickly as possible the available facts needed in preventing losses from plant diseases, especially of the staple food products and also to acquire as quickly as possible more necessary information, the board undertook to facilitate and encourage cooperative work among the men best fitted to attack the various problems involved. The essential features of the plan were voluntary offers of cooperation by the individuals and mutual agreement among the cooperators in the selection of a leader for each project. The results of the cooperative efforts inaugurated by the war board for the war emergency were so important and successful that the great majority of American pathologists have signified their desire to see the work continued as a permanent project. As a result, a new board called the advisory board of the society has been appointed and is specifically delegated to promote cooperative work among pathologists.

The familiar quotation from Shakespeare "There is a tide in the affairs of men which taken at the flood leads on to fortune" is especially applicable just now. If we interpret the signs correctly such a tide is now flowing and we should as scientists take all possible advantage of it. If according to the inscrutable plans by which the universe is guided, such a frightful slaughter as we have just witnessed was necessary in order to provide for the future advancement and welfare of humanity, it is not only an opportunity but a grave and imperative duty which presents itself at this time. The world as never before is looking to scientists for leadership, help and encouragement. The intellectual and spiritual battles which must be fought and won in the immediate future far surpass in importance the physical conflicts we have just passed through.

If the recently reorganized National Research Council lives up to the high aims set forth by the President in his executive order it will offer the greatest opportunity for organized cooperative effort in research that has ever occurred. It is to be hoped that it will be so supplied with the necessary funds and the support of all scientific investigators that it may fully demonstrate the advantages of cooperative effort in science.

Its measure of success must depend in great part upon the personnel of the council. The importance of this is clearly and forcibly expressed by Dr. Hale, the former chairman of the council, in his invitation to the scientific societies to nominate representatives for membership in the council. He says:

The future success of the National Research Council and the part to be taken by the United States in the International Research Council, of which it is the American member, will be chiefly determined by the representatives of the societies comprised in its membership. Recognized ability in research, wide understanding of its possibilities, keen interest in its promotion, and willingness to give time and thought to the work of the Research Council are the prime qualifications sought; whereas mere seniority in the profession, and scientific or technical activity without special interest in research, are evidently of themselves insufficient.

Every scientist and every scientific organization should take an active interest in the Research Council, giving it all the assistance possible, in order that it may carry out the great purposes for which it has been established. We should not only regard it as a great opportunity, but as a great obligation. The world is looking to us for cooperation and leadership in science as well as in political matters. Let us not disappoint it. We now have the necessary organization for cooperating with the various scientific organizations throughout the world. If this agency is properly utilized there should be a great acceleration in the advancement of science in the near future.

INDIVIDUALISM

It may appear to some that very little room is left in this scheme for individualism. The impression seems to prevail that there is a real conflict between the terms "cooperation" and "individualism." This we believe is due again to failure to properly define and understand the true significance and application of the terms. But a few years since, we were hearing much about the conflict between science and religion. To-day it is generally accepted that between true science and true religion there can be no conflict; both must have their basis in truth. The same may be said of cooperation and individualism. Between cooperation and individualism, in their proper application, there can be no conflict, for their aim is the discovery and application of truth. The chief problem is to determine the most effective manner in which each can be utilized in advancing science.

The fullest exercise of individual initiative, ability and expression in research, has in the past been most seriously interfered with by lack of encouragement and of funds and facilities, and by administrative restrictions.

It has been asserted that scientists, especially those endowed with extraordinary ability in research, should be free to follow unrestrained and unhampered wherever the spirit leads them. The best work in science as well as in art and literature must be primarily spontaneous and voluntary; but some guidance, some assistance and much encouragement may be given, the kind and amount depending upon the individuals involved and the problems under investigation.

Darwins and Edisons are rare. The future advancement of science must depend chiefly on the combined efforts of the mass of faithful seekers of truth whose names may never appear near the top of the scroll of honor of the world's greatest scientists.

Every effort should be made and every facility offered the individual investigator to utilize and develop in the most effective way all the ability for research which he may possess, but however brilliant the individual may be or however narrow or special his problem, cooperation in some form may be found advantageous. Individualism and originality should find full expression in the recognition of specific problems and their analysis and in the planning and carrying on of experiments and observations which give promise of leading to their solution or adding something of importance to the sum of human knowledge.

In general, special problems which do not require too great a diversity of knowledge of the various branches of science are best adapted to solution by individual effort, while broad and general problems can be more efficiently attacked by cooperation among individuals, each having free scope for the full exercise of his special training and ability in attacking some special phase of the general problem, the co-workers comparing results and coordinating their work by frequent conferences.

The applicability of cooperation and individualism in any particular case must be determined by the nature of the problem involved and the special ability and training of the investigators.

As we have tried to point out, there are plenty of problems and opportunities for the fullest exercise of the ability of the individual investigator as well as for cooperative efforts. The fundamental requirements for the success of either form of activity or combination of the two will depend largely upon the ideals and aims of the individual investigators involved. If their primary motives are love of research, the advancement of science and the improvement of mankind, there is not likely to arise any great difficulty in determining the best plan of work. If, however, baser motives dominate, the greatest success can not be attained.

IN REGARD TO SPECIES AND SPONGES

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IN the language of systematic zoology, species are particularly "difficult to distinguish" in certain genera, in many genera of sponges, for instance. Where this is so, it is in large part due to the fact that many specimens from various regions have been reported on. In such cases we begin to be face to face with the facts (of variation) as they are, not as they are assumed to be, when the species description rests on one or two specimens or on specimens from one locality.

A species in literature starts with the description of type specimens embodying a certain combination of characters, some of which are dimensional. As more or less similar specimens from different localities are studied, more and more such character combinations become known. These are of such a kind that, in sponges at least, if we consider any particular character, for instance the nature of the cortical canal spaces in the sponge *Donatia*, or the size and shape of the little spicules known as choanosomal asters in this genus, we shall often find, perhaps always find if we look long enough, forms that are intermediate between "species" in which the character in question has been regarded as a differential, that is, as a conspicuous mark of difference. That is, in respect to any one character there are species, and indeed often genera, which intergrade. Series of this kind indicate that the characters vary, or in the production of existing races *have* varied independently of one another.

As yet the most practical way of handling such complex data is to regard the race, usually geographical, which is represented by a described type, as the nucleus of a species that is gradually to be described. Round the race represented by the type specimens, and characterized by a certain character-combination, the so-called variations are gradually plotted. In this process racial or germinal marks are, it must be confessed, often confused through the limitations of the method with more purely somatic or environmental features. After a time, species-ideas emerge that are rich in content, and usable for all

kinds of biological work. Such species-ideas, however, owing to the way in which they have been built up, will undoubtedly sometimes overlap. When this becomes apparent, some rearrangement of the data (records) will be necessary, that shall be more in accord with the actual genetic relationships between the sponges and the causal nature of their differences. Such rearrangement, as we all know, has to be made from time to time. Species are combined, or distinct (hereditary) races within a species are distinguished, or marks that in the beginning were assumed to be racial are found to be age- or seasonal- or sex-marks, or the plain and simple results of a certain kind of local environment. All this is especially applicable to very inadequately known groups like the sponges, as it was equally applicable in former years to groups that are now better known. We must recognize, then, the necessity which is ever present with the classifier, of rearranging from time to time his categories.

In principle, systematists all agree with these ideas. Difference in actual practise comes in, however, when it is a question of assigning a place to a particular sponge or kind of sponge that has been described. Thus, to take an example, while very generally *Donatia ingalli* and *Donatia seychellensis*, the types of which differ noticeably in respect to the cortical anatomy, are retained as distinct species, some writers make them synonymous, viz., merge them. Of course, if in merging species the lines and magnitude of variation represented by particular races or strains (for so we may think of many literature species) are not lost sight of, no harm and often much good is done. But the merging can easily be arbitrary and artificial, as when only one or too few points of structure are considered, and the differences are slurred over, in which case distinctive characters that have been carefully recorded for this or that geographical region are lost sight of, and the process is simply the retrogressive one of "lumping" species together.

When one speaks of a species as embodying a certain character-combination, one may seem to be supporting the contention of Bateson, Lotsy and some others, that races are distinguished from one another as representing different combinations of germinal character-units, of units that have great stability; units which, moreover, are conceived of as comparatively limited in number and countable; units which are transported unchanged hither and thither through individual bodies, in the mazes of reproduction-cycles, combining, separating and

recombining again to produce by concerted action what formerly they produced (phenomenon of reversion). And it is undeniable that if we assume enough such units, we can use the hypothesis and possibly to advantage.

What is obvious, however, to the student of systematics and geographical distribution, although it must be frankly confessed that we are in the case of the sponges in great need of the intensive study of critical instances, is that racial features often vary up and down, apparently in response to the environment, in such a way as is possible only to easily alterable species-plasms.

One comes to symbolize the latter after the fashion of chemistry as complexes of atoms, molecules and radicals. Change in a complex may be pictured as due to the addition of more molecules or more radicals of a certain composition, or to a diminution in the number of such units. Or we may make the picture of fewer units, and think only of radicals which lose or gain atoms or simple molecules in response to environmental (external or internal) conditions, to "stimuli" as we say in physiological language. The radical thus varies up or down, and with it the features of the resulting organism. The rays of the small asters (chiasters) of *Donatia*, for instance, become obviously spinose at the tip, or are so minutely spinose that the fact is ascertainable only when an immersion objective is used, or are not spinose at all. In such a case, whether the germinal change be essentially one of a number of units, or quality of larger units, a graded series results, a series of idioplasms, of protoplasmic compounds, corresponding to the series of organisms which the study of differences exhibited by individual animals has led us to tabulate. The terms of such series actually in existence in nature at any one time may or may not be numerous. It would, however, seem, arguing from our knowledge that so many localities stamp with minute and yet distinguishable marks the individuals of a species living in such a region, that they often are very numerous. But whether numerous or few at any one time matters not. Artificial conditions bring into existence terms of the series never seen before, precisely as in the chemist's laboratory. And what does not exist to-day may come into existence in the future. Thus in respect to any character a series exists ideally, the terms of which are marked off from one another by minute, essentially dimensional, differences. Particular, easily distinguishable, terms of the series are recorded in systematics as among the

differential characteristics of species, when they occur with great constancy in a group of individuals; or as marking out a possible incipient species, when they occur only in some individuals, or when as in certain sponges they are represented only by some spicules of some individuals.

It is clear that the distinct categories of systematics or any classification, short of one that recognizes "individual-plasms," make an artificial set of frames for such boundlessly variable substances as are those that compose, let us say, the specks of protoplasm constituting the germ cells that will give rise to the organisms of the next generation.

It is no wonder, then, that although classifiers spend so much time in defining, viz., characterizing, particular species, no one can define the species-idea itself. Naturally this is so, because the species-idea is not precise, that is, it is not a definite complex of simple concepts, as was Linnæus's idea of species. The term stands only for a practical method of classifying things, which makes use, or tries to make use, of kinship as the chief guiding principle. Being of this practical character, it is in a measure apart from and implicitly contradictory of, our more precise physiological knowledge of nature, since its usage implies (of course, only on the face of things) that organisms do fall according to hereditary constitution into primary, separate groups of like significance. Nevertheless, as we all know, the employment of this practical rule, the species-idea, is a habit which helps toward the accomplishment of the great aims of biology, is indeed at present an indispensable tool in biological research.

The species-idea being of this kind, there is, of course, no definite number of species in the world, any more than there is a definite number of facts which, when found out, will constitute the perfect and closed book of a science. Reference is sometimes made to-day by biological writers to Linnæan species as if to groups of individuals that are qualitatively different from the groups which for convenience sake we put together under one name. Certainly the classifier of a group of organisms, as he extends his survey through the world, finds no counterpart in nature to an idea of a related set of individuals radically alike and radically different from all other sets.

What he finds is minute differences in the many times repeated, and superficially similar, structures of a single animal (the case of a sponge spicule, *e.g.*), differences between the individuals of a local race, and differences between groups of

individuals from different localities. Whatever distinction there is between individual (if hereditary) and specific differences, is one of degree not of kind. This is a commonplace in our book of principles, and has been since Darwin's time.¹ In the practise of the systematist the race is only a form "sufficiently constant and distinct from other forms to be capable of definition." And, as Darwin says,² if we call it a species, it is only because we regard its peculiarities as sufficiently important for the group of individuals exhibiting them to deserve a specific name.

It is convenient, as I have said, to use chemical symbolism. But what in the germ really underlies, what is the actual material basis of the individual differences which mark off races and species? Can we ever answer this question? Is it not simply one of those that turn upon the nature of matter, which physiological analysis of our sensations tells us need not, in strict logic, exist? At any rate, the kind of problem which we apparently can solve at the present stage of our mental development is not such as deals with the structural peculiarity in the idioplasm of the germ cell, the something which, if it exists, we may be allowed to call the final material cause of a character. It is rather how to produce the character, how to start and control the series of differentiations that lead up to its appearance. Growth and differentiation of the substance of germ cells and of tissues we certainly know something about, in the sense that our knowledge of these matters is perceptual knowledge and not symbolism, except in so far as all of our knowledge of matter is, to be sure, only a set of deductions, drawn from the interaction of ourselves and something which may or may not, we do not know, be what we now think of as matter. It is not misleading, it is not obscurantism, to point out that the "architecture of the germ plasm" about which we hear a good deal is for many (opinions differ—*vide infra*) a problem of a different kind from that which deals with the classification of germ plasms (idioplasms) on a basis of their perceptible properties, and with the laws that govern changes in these properties. These latter acquisitions of knowledge, although their form of expression, viz., the grouping of the facts, must needs be altered from time to time, rest on experience which repeats itself demonstrably when we wish, whereas the ultimate structure of an idioplasm will most probably forever lie within the field of symbolism. Such deductions follow after and fit them-

¹ Cf. "Origin of Species," sixth American edition, p. 412.

² "Origin," p. 425.

selves to experiential knowledge. It is the generalized results of the latter in the shape of comprehensive ideas or inductions, that tell us what we should expect in a concrete case and so lead to discovery. Beside these, theories as to the ultimate structure of this or that kind of matter are comparatively barren. And such theories should, I think, be more distinctly recognized for what they are, not over-rated and presented, as sometimes happens in inferior texts, in the guise almost of finalities, at any rate, as great, simple truths.

This feeling against the over-rating of theoretical explanation, with its concomitant effect on research in tending to develop the habit of substituting a partial conclusion drawn from one class of fact, for a thorough, comparative investigation of the phenomena, has been voiced in recent years by some of our leading thinkers.³ So over-rated is theory, so habituated do we become to its use in school, university and public speech-making, that, as we all know, it is deplorably common to find those who can not, try as they will, state their facts objectively. Such a schooling makes us all more or less inarticulate, except when allowed to speak in terms of our hypotheses, a condition which enormously increases the difficulty of ascertaining what has really been discovered in a field outside one's own. Goethe's verses, reading *experience* for *Leben* (although put in the mouth of Mephistopheles), are as true to-day as they were at the time of writing, when the imaginative portrayals by the biological logicians of the eighteenth century as to what goes on in development and inheritance, were so much nearer:

Grau, theurer Freund, ist alle Theorie,
Und grün des Lebens goldner Baum.

Finally, there is a question which all those who deal with the peculiarities and the classification of natural races and species do not answer in the same way. What place do the Mendelian genes occupy in our schema of the physiology of organic change, of the evolution of races? The gene is usually conceived as a self-propagating and stable particle of the germ plasm, which materially affects the sensible properties displayed by the organism into which a lump of such substance develops. It affects, at least in the speculations of T. H. Morgan and similar thinkers, not one but many such properties. The incorporation or loss of a gene is comparable to the incorporation or loss of a radical in an ordinary (non-living) organic compound.

³ Cf. W. K. Brooks *passim* and A. Agassiz in his presidential address before the International Zoological Congress in 1907.

In bi-sexual development corresponding genes repel one another in such a way as to fall in different germ cells. With this latter idea, the work of the systematist gives no familiarity, and I therefore pass it by, remarking only that doubtless all the facts of the inheritance of traits, even where there is great variation in the offspring, can be brought into conformity with it, if we adopt multiple-factor hypotheses and assume the presence in a germ cell of many genes which cooperate toward the same end; a whole block of such genes, perhaps, as in simple Mendelian heredity, acting as a unit and repelling a corresponding block, while under other circumstances the block is disorganized and the separate genes act independently of one another, thus leading to a greater variety in the offspring, as in cases of "blended inheritance." Or we may explain miscellaneous variation in the offspring by using some other form of accessory hypothesis, such as that which postulates the presence of primary character-producing genes and of other secondary genes which determine through their cooperation the degree in which the character is developed.

Viewed in general as a component of the idioplasm, the gene fits into our knowledge of the peculiarities that differentiate races, and a place is provided for it in the chemical representation of a "species-plasm," already referred to as a usable concept, and which dates back at least as far as Haeckel's "Generelle Morphologie," where such plasms are referred to as "organic compounds." It is, as several have pointed out, the material representative of what we more usually call a hereditary trait. The graded series, for instance, formed by related idioplasms, in the Chalinidæ, for example, in which sponges the skeletal fibers range from such as consist of many rows of spicules with but little spongin, through term after term up to fibers consisting only of spongin with no spicules, these graded series, met everywhere in the sponges, are describable, as I have said, in the terms of chemical symbolism. They are equally describable in the language of the gene theory. In the latter case, we picture genes, reserving speculation as to their ultimate relation to the chemical structure of the germ plasm, some for the production of spicules, some for the production of spongin, each kind present in considerable number and all cooperating to produce the fiber. Perhaps symbolism of this kind will prove useful in lending precision to our thinking when we come more widely in zoological work to the experimental task of analyzing through the production of new forms, the forces that bring about change in organisms.

Are genes countable or not? Sometimes writers speak as if they were. In the world of imagery, they undoubtedly are in strict logic, just as atoms and molecules are countable on the basis of certain premises in non-living substances. But the hereditary properties to which they give rise, and which, after all, as Castle in particular has emphasized, are the only facts of which we have any (perceptual) knowledge, are, as every student of nature must admit, not countable, for as soon as a new property has been discovered, it proves to be but a door that opens to the discovery of still others.

The gene-idea is, as we all know, very commonly, although by no means universally, linked up with chromosomes. And it must be said that the linkage, if it really exists, in nature, carries the idea quite out of the world of symbolism into that of cellular physiology, the "architecture of the germ plasm" becoming then a real object for experimental study and not a mere subject for logical imagery. But it will not do to forget that the facts at least permit us, if they do not force us, as some maintain, to look on the visible material particles (chromatin masses), with which "characters" are associated (and the progress of genetic and cytological researches seems unquestionably to show that such exist) not as determinants, but as differentiations—as indeed the first conspicuous differentiations that are made by the idioplasm in the course of the chains of events which lead to the appearance of particular characters. Viewed in this light, chromosomes lose that air of finality with which the Weismannian philosophy has invested them, but retain a very solid interest. Genes, however, recede into the invisible.

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The records that make up biology would be chaos without systematics. Doubtless all will admit that much. Again, the interest in discovering new forms of life, new races and species, which is an essential part of systematics, is a basic factor in revealing what Arthur Thomson calls the "web of life," the complex of friendly and disastrous influences which species exerts on species in the matter of living. What is not so generally realized is that the classifying spirit and method, which works under comparatively simple conditions in systematics, and finds therefore in this field a chance to grow, is something that is needed in every branch of biology, if we do not wish to remain content with very provisional and partial conclusions

concerning the causes of phenomena, conclusions which sometimes succeed one another with a rapidity that dazzles and confuses all but the few engaged in their manufacture. This is only saying that science is nothing unless comparative. Systematics has, therefore, I believe, a great educational value.

But what direct significance have the results of systematics for the study of the laws of change in the organic world? Systematics reveals, at least in sponges, that characters are independently subject to variations such that in respect to any one of them, individuals and races occur which form close series between far distant extremes. Such series are found everywhere in the group. They are doubtless in a measure phylogenetic series, in which the terms bear to one another the relation of ancestral species and descendant. But the kaleidoscopic combinations of characters displayed in many genera and families indicate that this is not always the real relation. In these instances, it would seem rather that the terms of the series represent only different degrees in the response to the environmental stimuli, which related idioplasms have carried out independently of one another. Systematics thus gives us all the time hints, in some cases misleading perhaps, as to what *species-plasms can do*, and as to the conditions under which such and such a thing is done. It is a good guide to experiment, without which the latter is apt to run off into vagaries.

IGNIS FATUUS

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AMONG the meteoric appearances which have puzzled man ever since he began to inquire into the relations of phenomena and which are still unexplainable is the *ignis fatuus*, *jack-o'-lantern* or *will-o'-the-wisp* as it has been variously called. Reference to this peculiar manifestation was much more frequent in the writings of one hundred years ago than it is at the present time and many people have come to think of it as a purely imaginary phenomenon, belonging in the same class with witches and fairies with which it is so frequently associated in literature. While there are, no doubt, many fanciful and highly colored accounts of this puzzling phenomenon, there are also many well-authenticated records of its observance by men thoroughly competent to pass upon its reality. There is, however, considerable divergence in the accounts of different observers, and it does not seem improbable that unfamiliar lights of different kinds have been classed under the same name.

Most observers speak of the *ignis fatuus* as a flame. Thus Benjamin Martin, in his "Philosophical Grammar," published in 1758, says:

Ignis Fatuus, i. e., the foolish Fire or Jack in a Lanthorn, when a fat unctuous vapour is kindled and wafted about by the motions of the Air, near the Surface of the Earth, like a Light in a Lanthorn,

and most definitions since that time seem to have followed this one as a pattern. However, Newton had long before distinguished between this light and a true flame. In the third book of his "Opticks" Newton propounds the following query:

The *Ignis Fatuus* is a Vapour shining without heat, and is there not the same difference between this Vapour and a Flame, as between rotten Wood shining without heat and burning Coals of Fire?

In 1728, Mr. Derham, who had undertaken a special study of *ignis fatui*, laid before the Royal Society a letter from Dr. Giacomo Beccari, of Bologna, to whom he had written for information concerning these mysterious appearances. Beccari says, in part:

What I am going to offer you, concerning these fiery appearances, is the result of several conversations I had upon this subject with several

experienced travellers, men of learning and reputation, whose sincerity I had no reason to mistrust. For my own farther satisfaction, ever since I received your commands, I have made it my business to speak with as many as I could light of, with such as travelled much in the mountains, and with others that observed them in plains, on purpose to see whether or no the difference of the place made any sensible difference in the appearance. I find upon the whole that they are pretty common in all the territory of *Bologna*. To begin with the plains, they are very frequently observed there; the country people call them *Cularsi*, probably from some fancied resemblance to those birds; and because they look upon them as birds, the belly and other parts of which are resplendent like our shining flies. They are most frequent in watery and morassy grounds; and there are some such places, where one may be almost sure of seeing them every night, if it be dark. In the fields near the bridge *Della Calcarata*, in a common, belonging to the parish of *S. Maria in dono*, north of *Bologna*, one of these fiery appearances is very often observed to move across the fields, coming from another bridge, called *Della fossa quadra*. There is another of them in the fields of *Bagnara*, almost east of *Bologna*, which scarce ever fails to appear in dark nights; particularly when it rains or snows; as also in cold and frosty weather: Both these, I mean that near the bridge of *Calcarata*, and that in the fields of *Bagnara*, are very large; and I am assured that sometimes their light is equal to that of one of our ordinary faggots, or bundles made of vine-branches; and that it is scarce ever less than that of the links which our country people make of hemp stalks, and which they light themselves withal, when they travel in the night. That at *Bagnara* appeared, not long since, to a Gentleman of my acquaintance, as he was travelling that way; it kept him company for a mile or better, constantly moving before him, and casting a stronger light on the road, than the link he had with him.

I believe there may be several more in other plains, as large as these two; tho' at present I have not been able to get certain information of any others. Lesser ones there appear a good many; some of them giving as much light, as a lighted torch; and some are no bigger than the flame of a common candle. Of these I have been assured a good many have been observed in the fields of *Barisella*. All of them have the same property, in resembling, both in colour and light, a flame strong enough to reflect a lustre upon neighboring objects all round. They are continually in motion; but this motion is various and uncertain. Sometimes they disappear of a sudden, and appear again in an instant in some other place. Commonly they keep hovering about six foot from the ground. As they differ in largeness, so do they in figure, spreading sometimes pretty wide, and then again contracting themselves. Sometimes breaking to all appearances into two, and a very little while after uniting again into one body; sometimes floating like waves, and letting drop some parts, like sparks out of a fire. I have been assured that there is no dark night all the year round, in which they do not appear. And in the very middle of winter, when the weather is very cold, and the ground covered with snow, they are observed more frequently than in the hottest summer. The Gentleman, who gave me an account of that at *Bagnara*, told me, that if I had a mind to see it myself, I might be sure of finding it, if I went thither in very cold weather; and in a sharp frost. Nor doth either rain nor snow in any wise prevent or hinder their appearance; On the contrary,

they are more frequently observed, and cast a stronger light in rainy and wet weather. This last circumstance, it is true, has been taken notice of by some writers, and among the rest, if I remember right, by the learned *Gassendus*. Nor does the wind much hurt them; tho' one should think, that if it were a burning substance, like common fire; it should either be dissipated in windy weather, or extinguished by rain. But since they do not receive any damage from wet weather; and since, on the other hand, it hath never been observed, that anything was thereby set on fire; tho' they must needs in their moving too and fro, meet with a good many combustible substances; it may thence be very reasonably inferred, that they have some resemblance to that sort of phosphorus, which doth, indeed, shine in the dark; but doth not burn anything, as common fire doth:

* * * * *

As to the appearance of this phenomenon in mountainous parts, by what I have hitherto been able to learn, they differ in nothing else but in largeness; and all those I conversed with, that saw them in the mountains, agree that they never observed any larger than the flame of an ordinary candle. Nor do those that live in the mountains call them *cularsi*, which name is, perhaps, us'd only by the country people in the plains for those large ones above described. The difference of the air, and that of the soil, may, for ought I know, contribute a great deal towards the different sizes of these appearances; at least all I can offer material at present towards solving this particular circumstance, namely with regard to their largeness, is, that those grounds where we observe the largest fires, as at *Bagnara*, are what they here call *strong ground* (*terreni forti*) being a hard, chalky and claiy soil, which will harbour the water a long while, and is afterwards, in hot wether, very apt to break into large cracks and fissures: Whereas on the contrary, those soils in the mountains, where they observe the small fires, are what they call soft, or *sweet ground* (*terreni dolci*) being generally sandy, and of a more loose contexture, which do not keep the water so long as the others. Of that sort also is the soil in the above mentioned plains of *Barisella*, where about 7 or 8 years before, they observed a good many of the smallest *ignes fatui* in the fields within the compass of about 3 miles.

The above excerpts from Beccari's letter probably give the best second-hand information available at that time to one who was interested in science and who lived in a region noted for the frequency of the phenomena under consideration. They seem to show that there were at that time regions where these luminous appearances were of frequent occurrence and of large size. They seem to show also that the people who were familiar with them recognized a difference between them and a true flame.

Alexander von Humboldt also calls attention to this distinction. He says that in Cumana, Venezuela, flames are frequently seen at night which are visible at a great distance, but which do not set fire to the dry grass. In most cases, at least, they seem to give off neither heat nor odor.

The one recorded observation which the present writer has

been able to find in which the observer claims to have shown that this light was a real flame is quoted in *Poggendorff's Annalen* from the Italian *Annali di fisica*, etc., of 1841. The article is in the form of a notice from Dr. Quirico Barilli Filopanti, of Bologna. Filopanti begins by referring to a statement which was made to him by the painter, Onofro Zanotti that while passing along a street a fiery ball with the appearance of a flame rose from between the stones of the street near his feet, passed so near him that he could feel the heat on his face, and then very quickly disappeared. Filopanti became greatly interested in the narration and determined to try to see one of these lights for himself. He accordingly spent many evenings watching for the phenomenon, especially in the neighborhood of church yards, which he was informed were favorable places for seeing them. He says that his vigils were rewarded by the sight of three. Of these he says:

The first was one of those which come out of the earth, rise to a certain height and then suddenly disappear. I can say little more of this than that it rose rapidly to a height of three or four meters and then disappeared with a faint report.

The second was carried by the wind horizontally, and was followed by me for some distance, when it was carried over the water of the Idice and then disappeared.

The third gave Filopanti an opportunity to test whether it was a real flame. He states that after watching for several evenings in a place said to be favorable to the appearance of these lights, at a place where hemp was being rotted in a small brook near a church, he went into a peasant's house one evening to take shelter from the rain, which was falling. While watching from a window, he saw the wished-for light, and seizing a long rod with some tow on the end, which he had prepared for the occasion, he ran out and approached the light. He described it as a smoky flame, about a decimeter in diameter, which was moving slowly from south to north. As he approached it, it began to rise, but he was able to thrust his tow into it and see it ignite. Very soon afterward the light went out. He says that the burning tow gave a faint odor which was not like phosphorus, but which seemed to him to be of a sulphurous character with some odor of ammonia.

In Volume 41 of *Poggendorff's Annalen* is a notice taken from *Comptes Rendus* which says:

On Sunday, Dec. 22, 1839, between five and nine o'clock in the evening, by mild and rainy weather, phosphorescent flames were seen to rise from slimy pools in the streets of Fontainebleau. These flames, when they rose from the water gave off a "crépitation" and wherever they were seen the

air was permeated with a strong odor of phosphorus. When the water from which the flames rose was stirred, it became phosphorescent.

This appearance, though classed under the head of *ignis fatuus*, was apparently quite a different phenomenon from those generally observed, as was the flame described by Filopanti.

A quite different description of an observation of these strange lights is given by the astronomer Bessel in a letter to the editor of *Poggendorff's Annalen* which was probably called out by the above notice. Bessel describes the observations which he made from a skiff on a small stream which flowed through a peat marsh as follows:

These appearances were observed by me on Dec. 2, 1807, early in the morning, on a very dark and calm night during which, from time to time, a gentle rain fell. They consisted of numerous little flames which appeared over ground which was covered in many places with standing water and which after they had glowed for a time disappeared. The color of these flames was somewhat bluish, similar to the flame of the impure hydrogen which is prepared by the action of dilute sulphuric acid on iron. Their luminosity must have been insignificant, since I could not observe that the ground under one of them was illuminated nor that the great numbers of them which frequently appeared at the same time produced a noticeable brightness. A closer estimate of their brightness I can not make, since the darkness of the night made my estimates of the distances of the flames very uncertain. Some of them, which seemed brighter than others, were estimated to be not more than fifteen or twenty steps distant, but this estimate is necessarily insecure.

As regards the number of flames which were visible at one time and as regards the period of their burning I can not speak with certainty, since both conditions were quite variable. I can only estimate as some hundreds the number visible at a time, and a quarter of a minute as the average period of their luminosity.

The flames frequently remained quiet in one position, and at other times they moved about horizontally. When motion occurred, numerous groups of the flames seemed to move together. I remember that one of the groups of flames suggested the moving of flocks of water birds.

Bessel describes the place where these observations were made as over a peat bog along a small brook. Much of the bog was covered with pits from which peat had been taken out, and pools of water stood in these depressions. It was over these pools that the lights appeared. He says that the boatman who was with him in the skiff, and who frequently carried peat through this marsh in the night, did not regard the appearance as at all unusual.

A similar observation to Bessel's was reported to the meteorologist Dove by *Schulrath Loeff*, of Gotha. The observations in question were made by a student for whom Loeff vouches. This student, Theodor List, was walking by night on a road

along the valley of the Fulda. The observation was described by List in part as follows:

The valley of the Fulda was covered by a heavy white fog, and a strong moldy smelling vapor filled the air. Suddenly, I saw a little flame scarcely two steps from me at the side of the road. I thought I must be deceived, but the moon was shining brightly and I was broad awake. To satisfy myself, I started toward the light, but when scarcely a foot distant it disappeared. But not a second had passed until I saw another, then a second, three, four, others. All the little flames remained quiet in one place and neither leaped nor danced. I observed that if the lights were not to disappear I must approach them very quietly, taking care not to set the air about them in motion. When I was very careful, I was often so fortunate as to bend over the little flames and observe their color and form at a distance of not more than a foot and a half. They were little flames of the size of a hen's egg, and they stood very quietly between the blades of grass. They were mostly of a greenish white light, and were fairly bright. I was able to seize some of them in my hand, but no heat was to be detected. If I waved a finger near them they disappeared at once. Many of them disappeared with a faint report, such as is made by the ignition of a bubble of phosphuretted hydrogen. Still, I must say that the air remained perfectly quiet.

A single flame seldom lasted longer than a minute and a half. The moon shone so brightly that I was able to read the dial of my watch. I could not have been deceived, for I observed the phenomenon very carefully and accurately. My eyes were completely clear, for I observed other objects about me and saw no lights between me and them.

A similar observation was reported by Galle as having been made by one of his students, Herr Vogel, of Leipzig. Vogel reports having seen *Irrlichter* twice, once along the marshy shores of a pond near Kamenz, and later just outside of Leipzig. The latter observations were made over a tract of marshy ground which received the drainage from some of the streets of the city, and through which a cut had recently been made by the Leipzig-Dresden Railway. The lights were seen in this railway cut. Vogel says:

After waiting for some time, I saw a faint light in the railway cut and observed a little flame about as bright as the vapor which is given off by a gently rubbed phosphorus match and very similar to this. This little flame disappeared very quickly, and after perhaps three seconds appeared again in the same place, and disappeared as before. I observed the phenomenon from a very close distance for several minutes without observing any odor. Likewise, I saw no smoke. The ditch was not filled with water, but its bottom was slimy. The little flames glowed about three inches above this slimy bottom, and were perhaps an inch high. The appearance was exactly similar to that which I had observed at Kamenz, only in that case the lights were much more numerous, so that it gave the appearance of the moon shining on rippling water.

Vogel states that the flames did not resemble those of spontaneously igniting phosphine, or of burning marsh gas.

A very different appearing *ignis fatuus* is described by Knorr, professor of physics at Kieff, as having been seen by him while a student at Berlin. Knorr describes two observations of these lights in his childhood, both of which correspond to the descriptions given by Bessel and List. The third seems to have been of quite a different character. This one, Knorr observed by the roadside at night where a bridge crossed a swampy stream. The light appeared in the grass over the marsh, and less than a foot beyond his reach when he lay on the ground. On account of the swampy nature of the bottom he feared to step into the marsh, but he lay near the light and observed it for a long time, passing his walking stick through it, and finally holding its ferule in the flame for fifteen minutes without it becoming appreciably warmed. He describes the light as of cylindrical form, perhaps five inches high and one and a half inches in diameter, standing quietly among the leaves of the marsh grass. He saw no smoke and observed no odor and the leaves of plants which were in the cylinder of light showed no signs of combustion. He describes the light as being bright enough to bring out plainly the surrounding foliage, though the night was very dark. The light did not seem to be easily disturbed by the movements of the air near it, and persisted until Knorr went on his way and left it.

Numerous other accounts of the appearance of these strange lights are probably familiar to the readers of this article, and many of them are, no doubt, of a fanciful character. Before the extensive draining of marshes over the earth, when these lights were more numerous than at the present time, they were regarded with superstitious fear by many of the people who most frequently saw them, and their accounts of them are, no doubt, frequently colored by this fear. One form of this superstition is shown in the name "corpse candle," which was applied to these lights in some localities.

Apparently different kinds of lights have been observed at different times. Certainly, the smoky flame described by Filopanti was quite different from the little clouds of luminous vapor described by Bessel, List, Vogel and Knorr. The present writer, when a child, was told by his father of lights which the latter had seen over a peaty pond in Ohio, and his description was similar to that given by Bessel, except that the observed lights were very few in number.

These little vaporous clouds seem to possess none of the characteristics of a flame of any kind. They are frequently spoken of as some kind of an electrical glow, and for the same

reason that many other phenomena which we can not explain are guessed to be electrical in their nature. However, the conditions under which these lights are seen are as far as possible from any under which an electrical glow is known to exist.

To the present writer, there seems but one probable explanation of these obscure phenomena, and that is that they are little swarms of luminous bacteria which are carried up from the bottom of the marsh by rising bubbles of gas. Many kinds of luminous bacteria are known and the marshes from which these lights arise are known to be the favored habitat of some of these kinds. Some, at least, of these bacteria do not become luminous until exposed to the oxygen of the air. This seems to be true of the bacteria which cause the luminosity of rotten wood, the "fox fire" of our boyhood.

In Volume 2 of *Nicholson's Journal* is described a rather extensive series of experiments by Nathaniel Hulme on luminous wood, fish, etc., in various gases. Hulme found that only air or gases from which oxygen could be derived would support the luminosity. It could be completely quenched in hydrogen, but after several hours immersion in this gas it would appear again if exposed to air or oxygen. Certain it is that bubbles of marsh gas and carbon dioxide gas are almost continuously rising from peaty marshes. The former, being lighter than air would carry its colony of bacteria rapidly upward until they were dissipated by diffusion. The latter, being heavier than air, would remain for sometime near the surface of the water, and would diffuse into the air much more slowly. Whatever would set up a circulation in the water would tend to dislodge these gas bubbles with their charges of bacteria from the bottom. Was not Newton probably right in his suggestion that there is "the same difference between this Vapour and Flame as between rotten wood shining without heat and burning Coals of Fire"?

LINKAGES

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A HISTORICAL study of linkages starts with the work of James Watt, although the pantagraph and lazy-tongs, both familiar cases of simple linkworks, were known at least as early as the seventeenth century. In his improvements upon the steam-engine the Scottish engineer found it necessary to guide the piston-rod in a straight line, and yet to communicate its motion to the circular movement of the working-beam. A diagram of his invention of the purpose is shown in Figure 1; the combination of three links provided an approximate rectilinear motion whose "sweet simplicity" was astonishing when contrasted to the double chains or racks and sectors which it replaced. In a letter to his son upon the subject he concludes,

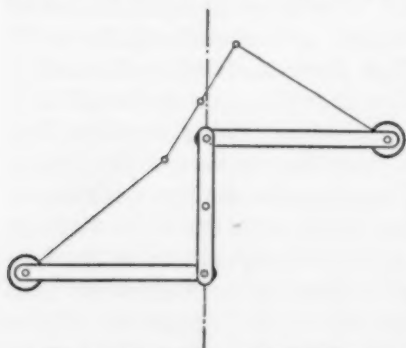


FIG. 1. WATT'S PARALLEL MOTION.

"Though I am not over anxious after fame, yet I am more proud of the parallel motion than of any other mechanical invention I have ever made."¹ Such praise from Watt is praise indeed; his interest in link motions was a lasting one, and he spent the later years of his long and splendid life in perfecting a machine for copying sculptures, a sort of pantagraph in space, which

was to act with all the "delicate smoothness" of the parallel motion.

It was in the "latter end of 1783" that Watt devised the application to the steam-engine, but, in spite of the fact that it was almost universally used, very few adaptations or other combinations of links for the conversion of motion were tried for many years. Examples of Watt's parallelogram were given by engineering writers, such as the famous and influ-

¹ See D. H. Leavens, *Am. Math. Monthly*, Vol. 22, 1915, p. 331. He quotes from J. P. Muirhead, "Life of James Watt," New York, Appleton, 1859, p. 242. The reference to the second edition (London, 1859) is p. 288.

ential Frenchman, Prony,² but no comprehensive investigation was made until the middle of the nineteenth century, when the impulse came from the University of St. Petersburg.

In 1847 Pafnouty Lvovitch Tchebychef obtained a position at the University of St. Petersburg, and became able to indulge somewhat an interest he had pursued from a child,³ the construction of mechanisms and models of his own invention. In the vacation of 1852 he took a trip through Western Europe to visit factories, to see different types of mechanisms and, most of all, to study Watt's parallel motion; towards the close of the summer he crossed the Channel to pay his respects to Cayley and Sylvester, and to Gregory the engineer. In London, Tchebychef hunted up some of Watt's original machines, preserved in the Royal Polytechnic Institute, and satisfied his inquiry by measuring the lengths of all accessible parts, and studying the details of the various arrangements.

On his return to Russia Tchebychef devoted a large part of his time and enthusiasm to the question of providing an analytical method for handling such motions as that of Watt's parallelogram. Recognizing the advantages of a geometrical insight into such motions, he nevertheless regretted the difficulty of a geometrical grasp of the subject, and for himself preferred methods of analysis. His own methods were remarkably clever, if somewhat prolix; and they enabled him to devise new motions whose deviations from a straight line were given in terms of arbitrary constants of the linkwork, and which were so inconsiderable as to be within the limits of mechanical accuracy.

But although these approximations may have been satisfactory from the point of view of mechanical motion, they were by no means a sufficient solution of the problem of drawing an exactly straight line. To accomplish this Tchebychef's analysis was unavailing. So far three links had been employed in every model, and the curve traced by points upon the traversing bar was beginning to be studied, a sextic of an analytically unattractive appearance. It was hardly likely that a five-bar linkwork, or a more complicated model, would produce a more simple result. Indeed, for more than three links Tchebychef's analysis grew so involved that a linear solution was extremely

² "Nouvelle Architecture Hydraulique," 1796, t. 2, p. 123. See Muirhead, second edition, p. 261. The terms "parallel motion" and "parallelogram," though not at all descriptive, are used throughout the early literature, and may therefore be retained here.

³ A biographical sketch is given in *Oeuvres de P. L. Tchebychef*, St. Petersburg, t. 2 (1907), pp. i-vi, and his account of the trip, pp. vii-xix. (Cf. Leavens, *loc. cit.*)

improbable; and when he became certain that no three-bar motion could trace a straight line, he is said to have considered it impossible to produce rectilinear motion by any linkwork.*

But in this result the eminent Russian scientist decided "with less than his usual success in overcoming difficulties insuperable to the rest of the world," and it seems as though the spirit of science was merely waiting for this confession of inability to bring to men's attention the simplicity of the true solution. The first rectilinear motion by linkages was invented by Lieutenant Peaucellier, a young French officer of engineers detailed for the moment, and possibly with consequent leisure, to staff duty; a subsequent discovery was made by L. Lipkin, a freshman at the University of St. Petersburg, who was studying mechanics under Professor Tchebychef. Peaucellier's discovery was made about 1864, Lipkin's in 1870; and an interesting fact is that, although the two were independent, their methods and linkworks were precisely the same.

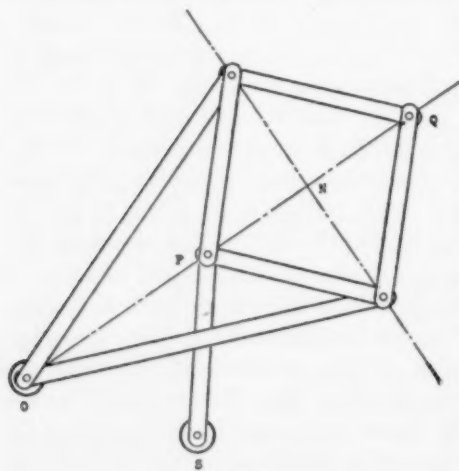


FIG. 2.

The linkwork of Peaucellier and Lipkin jumps from three to seven links. There are first of all two long links of equal length, both pivoted to the same fixed point; their other extremities are pivoted to opposite angles of a rhombus composed of four equal shorter links, as shown in Fig. 2. The portion of the linkage so far described is the essential part, and is called Peaucellier cell; by means of a seventh and extra link the

cell is made to move so that the free end of the rhombus describes an accurately straight line.

The reasoning to prove this is very simple and depends upon a fundamental property of geometrical inversion. It is evident that whatever shape and position the linkage assumes, the points *O*, *P*, *Q* will always be on a line; and if *N* be the intersection of the diagonals of the rhombus,

* See J. J. Sylvester, "On Recent Discoveries in Mechanical Conversion of Motion," *Proc. Roy. Inst.*, Vol. VII., pp. 181 and 183, footnotes.

$$OA^2 = ON^2 + AN^2$$

$$AQ^2 = QN^2 + AN^2$$

so that

$$\begin{aligned} OA^2 - AQ^2 &= ON^2 - QN^2 \\ &= (ON - QN)(ON + QN) \\ &= OP \cdot OQ \end{aligned}$$

Hence if O is pivoted to a fixed base, since OA and AQ are the constant and arbitrary lengths of the links, the product

$$OP \cdot OQ = \text{constant}$$

so that whatever the shape of the cell, P and Q are inverse points with respect to a circle whose center is at O ; and whatever curve P is made to trace, its inverse curve will be traced by Q .

So stated, the remainder of the problem is not difficult; for if we want Q to trace a line, an easy way will be to make P trace a circle passing through O , since the inverse of any circle through the center of inversion is a line. Hence the extra link, pivoted to P and to a fixed point S whose distances from O and P are equal. Then any motion of the linkwork will cause P to move on a circle through O , and Q will move along a line.

This pretty solution of the problem of rectilinear motion was published by Peaucellier in 1864; unfortunately not in a complete form, but merely as an announcement in the *Nouvelles Annales* for that year; and coming as it did from an unrecognized person in an unorthodox way it was "successfully concealed under a wrong entry." At any rate, the little announcement was quite overlooked by those interested, until six years later when the work was duplicated by the Russian student. Then Professor Tchebychef's admiration for the work of his pupil, although it confuted his own analysis, secured for Lipkin a handsome reward from the Russian Government. Tchebychef's enthusiasm communicated the results to his friends in France and England, and the stock in linkages rose. The hitherto unrecognized Peaucellier, now a colonel in command at Toul, was exhumed from his dugouts and awarded the famous "Prix Montyon" of the Institute of France; and it appears that the two young men who are here linked together for their independent yet similar abilities, were similarly sated by success, for neither Peaucellier nor Lipkin is again heard of in the history of science.

But if the younger men were resting quietly upon their laurels, their work was seized upon with complimentary rapidity by men of more maturity and standing; and at this juncture

the London school of mathematics became interested in the results which had hitherto been confined to engineers, and mostly obtained upon the continent. In 1869 Samuel Roberts suggested the connection between geometry and linkages in a paper read before the society "On the Mechanical Description" of certain curves.⁵

Mr. Roberts chose as his text the saying of Newton, "At æquatio non est, sed descriptio, quæ curvam Geometricam efficit," and considered that "in the present state of the theory of quartic and cubic curves, it is very desirable that we should be able to draw them continuously." He cited the classic examples of Nicomedes' Trammel for drawing the conchoid, Newton's method for the cissoid, and Pascal's for the limaçon. By generalizing these methods some interesting results were obtained; and among the more important results was the fact that Cayley became interested in the drawing of curves, and began a discussion of the three-bar curve, or the curve traced by any three-bar linkwork such as that of Watt.

The time was ripe for the introduction of Peaucellier's motion into England, and perhaps the dramatic way in which it was rediscovered by Lipkin had something to do with the interest it aroused. Consider the effect of a sincere statement by an eminent man that it was impossible to convert circular into rectilinear motion, a statement, by the way, which was confused by many with the squaring of the circle; and when this noted man had been for some time buried in a mass of computation to prove his point, a timid freshman raps upon the door, presenting to his eyes the thing itself, and not the proof of its impossibility. It was very likely this paradoxical entrance that pleased Sylvester. At any rate, Sylvester took up the invention with enthusiasm, enlisted Professor Henrici's services to procure him models, and at the annual general meeting of the London Mathematical Society in 1873 he gave a talk which was, by the secretary's account, "warmly applauded."⁶ Following that, he made a well-known address⁷ at the Royal Institute to a more general audience; and the enthusiasm with which that facile scientist spoke upon the subject to every one he met played a great part in its popularity, and the practical application which he foretold lent to it a specious importance.

The interest which Sylvester himself took in linkages is well

⁵ S. Roberts, *Proc. Lond. Math. Soc.*, Vol. 2, 1869, p. 125.

⁶ *Proc. Lond. Math. Soc.*, Vol. 5, p. 4.

⁷ J. J. Sylvester, "On Recent Discoveries in Mechanical Conversion of Motion," *Proc. Roy. Inst.*, Vol. 7, p. 179; or "Collected Works," Vol. 3, p. 7.

attested by the address mentioned above; taken down by the secretary, it was probably given to the speaker for annotation; and when returned to the secretary for publication it had considerably more than five times as much in the footnotes as in the text, with a postscript superadded. In this postscript were included his "kinematical paradox" for representing a constant as a kinematical function of the independent variable, and several schemes for representing crystallographic and atomic groupings by means of linkages. "It would be difficult to quote any other discovery," he writes, "which opens out such vast and varied horizons as this of Peaucellier—in one direction, as has been shown, descending to the wants of the workshop, the simplification of the steam-engine, the revolutionizing of the millwright's trade, the amelioration of garden-pumps, and other domestic convenience (the sun of science glorifies all it shines upon), and in the other soaring to the sublimest heights of the most advanced doctrines of modern analysis, lending aid to, and throwing light from a totally unsuspected quarter on the researches of such men as Abel, Rieman, Clebsch, Grassman, and Cayley. Its head towers above the clouds, while its feet plunge into the bowels of the earth."⁸

Although Sylvester's words read rather like an advertisement than sober science, his enthusiasm was adopted by many round him and the models were admired by many more. He showed a model of Peaucellier's cell to Sir William Thomson, and according to Sylvester the canny Scot "nursed it as if it had been his own child, and when a motion was made to relieve him of it, replied, 'No! I have not had nearly enough of it—it is the most beautiful thing I have ever seen in my life.'"⁹ Considering the extraordinary conversions worked with the model, Sylvester considered that "it would not be unsuitable to write in letters of gold on the board attached to it which gives support to the two frail centers, the famous motto of Constantine—'In hoc signo vinces.'"

With Sylvester pushing the subject from one side and Cayley from the other, the interest in linkages could not fail to be keen, and many other men were drawn to the subject; A. B. Kempe and Harry Hart in England, Lemoine and Brocard on the continent, Woolsey Johnson in America, and an even more notable trio, Darboux, Clifford and G. H. Darwin. Within ten years close to one hundred and fifty papers had been published

⁸ Sylvester, *loc. cit.*, p. 195. His spelling, Rieman and Grassman, is preserved.

⁹ Sylvester, *loc. cit.*, p. 183.

in recognized journals;¹⁰ and if a curve is plotted as in Fig. 3 to show how many papers were published every year, as an indication of the interest, such a curve would show a remarkable rise during 1874, and its culmination reached in 1875 with thirty-six articles published in that year. The rapid rise of

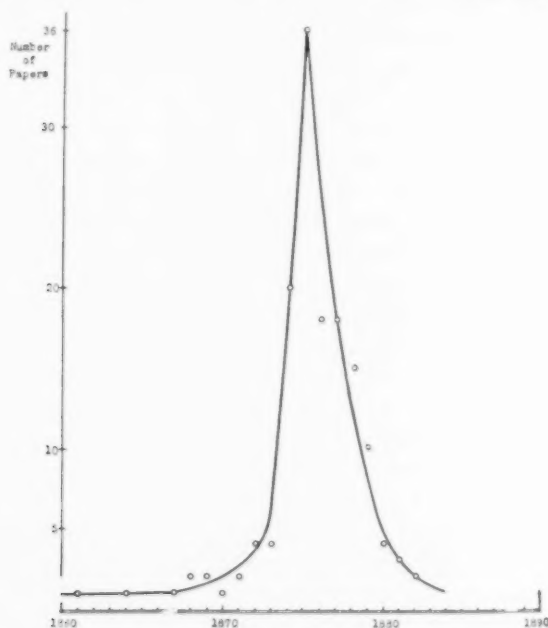


FIG. 3.

the curve is no more remarkable than its sudden fall; and the shape in general is typical of an explosive epidemic, due to powerful causes, and rapidly running its course to a conclusion.

Peaucellier's motion was introduced by Sylvester into England in 1873, and many up to date mechanics seized upon the principle. Some circular steps outside St. Paul's Cathedral were so worn as to require repair, and the surveyor used a cell, adjusted to circular instead of rectilinear motion, to cut the templets; and though the radius of the steps was about forty feet, the cell operated "to the great comfort and delectation of his clerk" with a link some six feet long.¹¹ It was, by the way, this same surveyor whose pump was "ameliorated" by Peaucellier's principle. And a little later came the classic example which all students of linkages quote, the application of the motion to the air engines which ventilate the House of Parliament.

¹⁰ V. Liguine, *Bull. Sci. Math.*, 2d series, Vol. 7, 1883, p. 145, gives a bibliography of 151 papers up to 1882.

¹¹ Sylvester, *Proc. Roy. Inst.*, *loc. cit.*, p. 182.

In August of 1874 Harry Hart of Woolwich Academy disproved Tchebychef's last entrenchment¹² by showing that Peaucellier's cell of six links could be replaced by a new linkage of only four bars. Hart's linkage was obtained by crossing the links of an ordinary jointed parallelogram, as in Fig. 4, form-

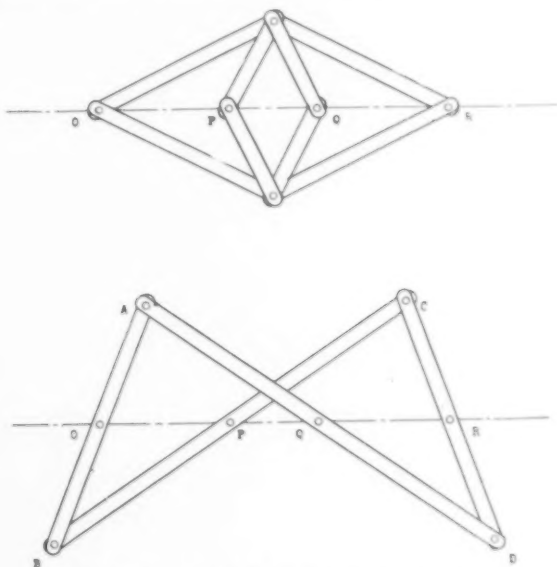


FIG. 4. HART'S CONTRA-PARALLELOGRAM.

ing what is called a contra-parallelogram. Then the four midpoints¹³ have exactly the properties of the points of a Peaucellier cell to which two long links have been added for symmetry; and it follows that a five-bar rectilinear motion may be produced from Hart's contra-parallelogram by the addition of an extra link.¹⁴

So far linkages had been studied from an experimental standpoint, as arrangements of a certain number of rods and pivots; but about this time Samuel Roberts suggested that instead of considering the motion of jointed rods it would be better to consider the motion of the planes associated with those rods, for the order of the path-curves would not thereby be increased. Sylvester then substituted the more general idea

¹² Tchebychef stated the impossibility of five-bar rectilinear motion, even after Peaucellier's discovery was known. See Sylvester, *loc. cit.*, p. 181.

¹³ Or any points whose ratio $AO:OB$ is constant.

¹⁴ A different and pretty five-bar linkwork for drawing a straight line was given by M. Raoul Bricard in 1895 [*Comptes Rendus*, 120, p. 69], but as not related to the general story of the epidemic it is not included here.

of the relative, as distinguished from the absolute, motion of plane upon plane; a conception which is fruitful in indicating that link-motion may be reduced to the rolling of centrodes.¹⁵

In studying the ordinary three-bar motion it had occurred



FIG. 5. PANTOGRAPH.

to Kempe¹⁶ to consider what happened when the traversing bar and one of the radial bars had changed places, and the conclusion reached without difficulty was that the order in which the bars are chosen does not affect the shape of the path-curve. If, in Fig. 5, OC , CB , BS be the original three bars, and P a point on the traversing bar tracing a certain curve; then if the two bars OA , equal to CB , and AB , equal to OC , are added, and Q is on AB such that

$$QO : PO = AO : CO,$$

Q will trace a curve similar in shape and position to that traced by P , but enlarged in the fixed ratio. And if the bars OC and CB are taken away there remains a three-bar linkwork which is the same as the old except that the radial link and the traversing link are interchanged. This was remarked by Sylvester as a most acute and admirable theorem; but is also, as Cayley

¹⁵ See Sylvester, "History of the Plagiograph," *Nature*, Vol. 12, 1875, p. 214, footnote.

¹⁶ A. B. Kempe, "How to Draw a Straight Line," London, Macmillan, 1877, p. 20; Sylvester, *loc. cit.*, p. 215.

observed when Sylvester consulted him, a self-evident deduction from the principle of the ordinary pantagraph.

The result obtained by Kempe, when communicated to Sylvester, was immediately seen by the latter to be extensible to the case of three-piece motion, where the bars are replaced by their planes; and Sylvester's skew pantagraph or "plagiograph" is obtained by making P and Q similarly situated in the

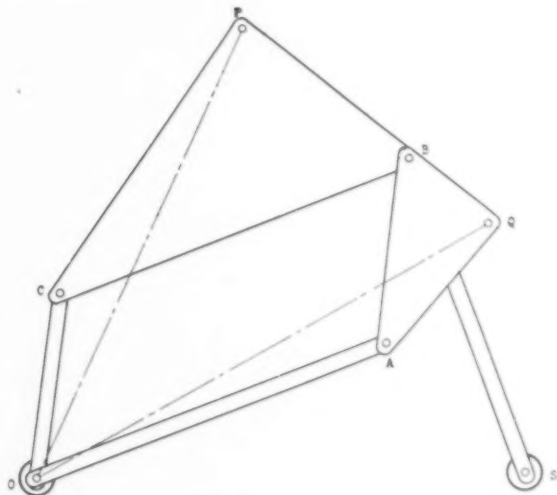


FIG. 6. PLAGIOGRAPH.

planes of CB and AB , as by making the triangles CPB and AQB similar, in Fig. 6. Then P and Q trace curves which are similar, but turned through a fixed angle.

It is a natural conclusion that the principle of the plagiograph might be applicable to Hart's contra-parallelogram, and both Kempe and Sylvester, the one "by the free play of his vivacious geometrical imagination," the other "by the sure and fatal march of algebraical analysis," found that if a chain of similar triangles be attached to the four links, the free vertices will form a parallelogram whose angles are invariable and whose area is constant. For instance, to use the same lettering in Fig. 7 as in Fig. 4, if O, P, Q, R are the vertices of isosceles right triangles fixed to the bars AB, BC, AD, CD , then $OPQR$ is always a rectangle of constant area. The linkage is, by Sylvester's name, a "quadruplane."

The quadruplane affords much light upon three-bar motion, which results when any one plane is held fixed. If, for example, AB is fixed, then I will be the instantaneous center, and

$$AI + BI = BI + CI = BC, \text{ a constant,}$$

so that the point I describes upon the fixed plane an ellipse of

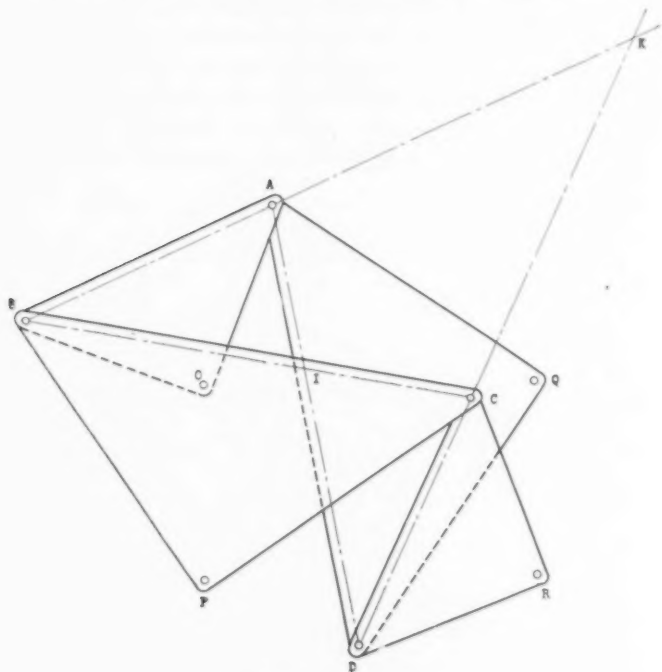


FIG. 7. QUADRUPLANE.

which A, B are the foci and BC the length of the major axis. In a similar manner

$$CI + DI = DA$$

and the locus of I on the moving or traversing plane CD is an equal and similar ellipse. Hence the relative motion of the two opposite planes AB, CD , is that produced by the rolling of two equal and similar ellipses.

The two planes BC, AD have their instantaneous center at K ; the trace of K upon the plane BC is given by

$$BC - CN = BN - AN = BA,$$

an hyperbola, and its trace upon the plane AD is an equal and similar hyperbola. It follows that the free motion of the quadruplane, or the relative motion of four planes so linked, reduces to the double rolling of two ellipses and two hyperbolas.

This conception of three-bar curves being produced by the rolling of two equal conics shows that the particular quartics produced are related to the inverses of conics, and simplifies the discussion considerably; and in broad terms this represents the state of knowledge of three-bar motion through the middle of

1875, when Sylvester had published an article in *Nature*. In November of that year Samuel Roberts made an important observation in the theory of three-bar motion proper, or the motion of three links about two fixed pivots. Noticing that the pivoted points turn up as singular foci in the discussion of the sextic path-curves, and that there are three foci to the sextic, he suggested that the two pivots might be placed at any two of the three foci, and by means of links of suitable lengths the same locus would be obtained. In other words, any path described by a point moving with three-bar motion may also be described in two other ways by three-bar motion.¹⁷

Whatever the merits of Mr. Roberts per se—and this observation was singularly acute—he seems to have had the important ability to interest Professor Cayley; and once again Cayley was led to an investigation of three-bar curves by a consideration of Roberts's results. In March of 1876 he put the above theorem into the following elegant form.¹⁸ Take any triangle ABC and through any point O within it draw lines KF , EH , GD parallel to the sides. Let the triangles HKO , GOF , ODE be supposed rigid and jointed together at O , and let the other lines in the figure represent bars forming three jointed parallelograms, as shown in Fig. 8. Then however the system is moved about in its plane the triangle ABC will always be of the same shape; and further, that starting from any given position of the three triangles, the linkage may be so moved as not to alter the triangle ABC in magnitude; so that when the three points A , B , C are fixed in any other than their maximum position, the point O will still remain movable. In so moving, O will describe a path which is due at the same time to three different three-bar motions.

These pretty results were proved by Cayley with a somewhat forbidding nomenclature, and Clifford, who usually sat in the back of the room and said little at the meetings of the society, gives a very much simpler discussion in his "Kinematic."¹⁹ But the two papers which Cayley read at this time contain much information on the three-bar curve; and, though they by no means say the last word upon the subject, no further word was said for quite a time. For reference once more to Fig. 3 will show that in 1876 the interest in linkages had passed its climacteric, and that the number of papers published and

¹⁷ S. Roberts, *Proc. Lond. Math. Soc.*, Vol. 7, p. 17.

¹⁸ Cayley, *Proc. Lond. Math. Soc.*, Vol. 7, 1876, p. 136; cf. Clifford, "Kinematic," p. 149.

¹⁹ Clifford, *loc. cit.* Curiously enough, the same simplification was published as original by Hart [*Camb. Mess. Math.*, Vol. 12, 1882, p. 32], while Clifford's "Kinematic," surely a widely read book, came out in 1878.

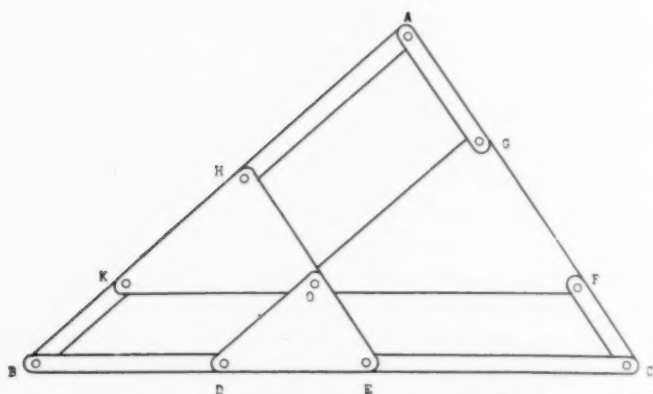


FIG. 8. TRIPLE GENERATION OF THREE-BAR MOTION.

new results obtained was rapidly diminishing. One stopping point upon the downward course occurred when Kempe proved the rather remarkable theorem that any algebraic curve whatever can be described by a linkwork, and his analysis is as beautiful as his result is elegant.²⁰ But after that the enthusiasm fell as fast as it had risen, and the epidemic, as far as history is concerned, was over.

Sir William Osler quotes Sidney Smith as saying, it is not the man who first says a thing, but it is he who says it so long, so loudly, and so clearly that he compels men to hear him—it is to him that the credit belongs; and so far as this singular epidemic of linkages is concerned, the credit for its existence belongs to Sylvester. It was through his efforts that other great minds turned to the subject; and indeed, the subject is made more interesting than many other offshoots of science only by the notable character of its contributors. And it may be more than a coincidence that the epidemic failed just at the time when Sylvester became involved in building up a new department in another land. The students at the Johns Hopkins University were interested in other lines, and though there are several papers on linkages in the *American Journal of Mathematics*, there are none of great importance. In England, Cayley and Kempe were diverted to map-coloring and the study of groups; of the younger men, Darwin found another line more suited to his taste, and the incomparable Clifford died before we had a chance to learn what he might have done. With the loss of the contributions of these leaders the first chapter of a study of linkages may close.

²⁰ Kempe, *Proc. Lond. Math. Soc.*, Vol. 7, 1876, p. 213.

THE PROGRESS OF SCIENCE

LORD RAYLEIGH

THE death of John William Strutt, third Baron Rayleigh, closes a career of remarkable scientific distinction and may mark the ending of an era in science and in civilization of which he was one of the finest representatives. The loss of the environment supplying men such as Darwin and Rayleigh is part of the price that must be paid for industrial democracy, developing through the nineteenth century and now rising to sudden supremacy through the catastrophe of war.

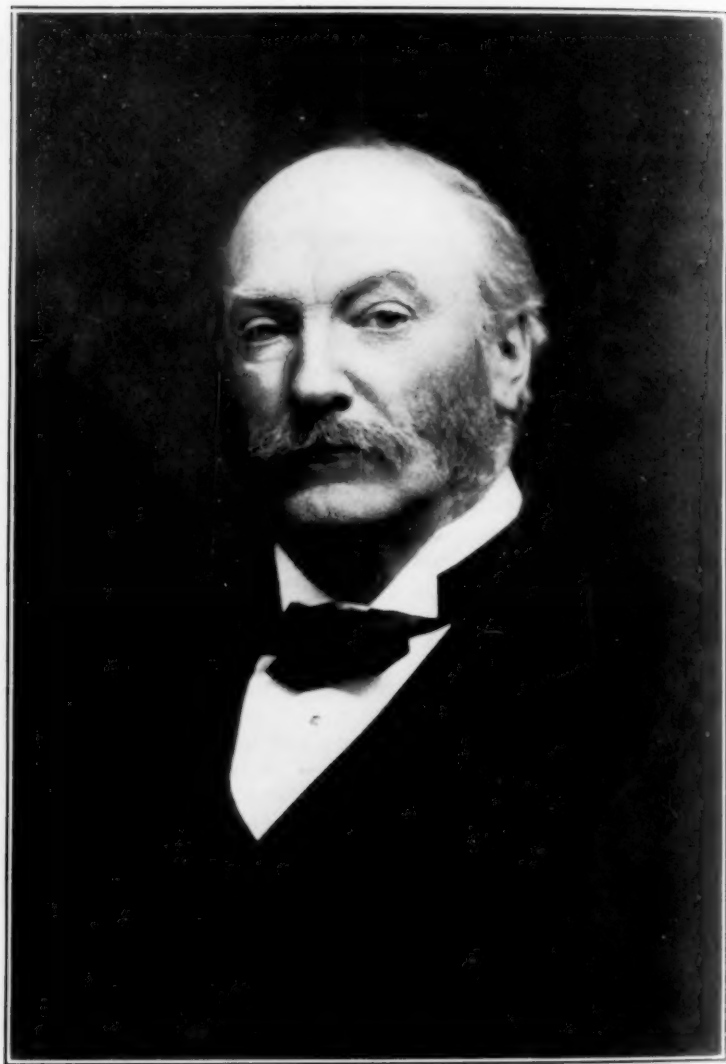
A significant part of the Victorian England was the life and work of its two great universities. Strutt entered Trinity College, Cambridge, nearly sixty years ago, and received his degree as senior wrangler in 1865, twenty years after William Thomson, later Baron Kelvin, had been second wrangler. The remarkable selective power of the Cambridge mathematical tripos examination is further shown by the fact that the senior wrangler in Thomson's year, Perkinson, was a mathematician of distinction, while the second wrangler, following Strutt, was Alfred Marshall, also later professor at Cambridge and England's most distinguished economist.

Rayleigh married Evelyn Balfour, who was a niece of the Marquis of Salisbury, author, prime minister and president of the British Association; she was a sister of Mr. Balfour, also author, prime minister and president of the British Association. The two other brothers of Lady Balfour were also distinguished, Francis Balfour, professor of animal morphology at Cambridge, being a brilliant investigator. Her sister, Mrs. Henry Sidgwick, wife

of the distinguished Cambridge professor of ethics, was an able scientific writer and investigator, becoming later principal of Newnham College. The oldest son of Lord and Lady Rayleigh, who now inherits the title, is professor of physics in the London Imperial College of Technology and the author of important contributions to the science.

Clerk Maxwell, the great mathematical physicist, was the first Cavendish professor of physics at Cambridge. On his death in 1879 he was succeeded by Rayleigh who held the chair for five years only. His student Sir J. J. Thomson, succeeded him at the age of twenty-seven. Thomson retired this year from the chair to which his student, Professor Rutherford, has now been elected. It would perhaps be impossible to name a chair in any subject or in any university held in succession by four men of such distinguished performance. The family and academic relations of Rayleigh indeed witness the efflorescence of the aristocratic tradition.

Rayleigh established his laboratory at Terling Place on his eight thousand acres of land and did his work, usually with simple apparatus. His book on the "Theory of Sound" is a classic. His "Collected Papers," published in five volumes in 1910, comprise 349 titles, and, as he continued to publish without cease, his recent papers will fill a further volume. Each of these papers is a contribution to knowledge; none of them is commonplace. To the general public Rayleigh is best known for the discovery of argon which opened a new chapter in physics. This he accomplished simply by the use of the balance, finding a new



LORD RAYLEIGH.

element truly as common as air, for it forms one two-hundredths of the atmosphere.

Rayleigh was for eighteen years professor of natural philosophy at the Royal Institution; he was for eleven years secretary and for five years president of the Royal Society; he was president of the British Association when it visited Montreal in 1884; he was chancellor of the University of Cambridge until his death; he received a Nobel Prize and all the honors that go to men of science. During the war and when over eighty he rendered great service to the progress of aviation as chairman of the National Committee on Aeronautics. With unusual truthfulness it can be said "we shall not look upon his like again," for the scientific and social conditions of his life will not recur.

REFORM OF THE ENGLISH UNIVERSITIES

FROM the days of Newton to Kelvin, Stokes, Maxwell, Rayleigh, Thomson, Rutherford and Larmor, the University of Cambridge has

been the home of mathematical physics. Newton entered Trinity College in 1666, and was elected a fellow in 1667. During the subsequent two hundred years until Rayleigh was elected to a fellowship in 1866, the college, which was especially frequented by the sons of the nobility and of the upper classes, produced a long line of men of distinction, including many mathematicians. Sir J. J. Thomson, second wrangler in 1880, was elected to a fellowship in that year and is now master of the college.

Oxford and Cambridge, which with about one tenth of the number of the students claimed by Columbia, have been responsible for the education of more than one half the leaders of England, and England has had more great men than any other nation. It is a noteworthy circumstance that these universities, medieval not only in religion but also in their whole outlook on life, should have this record. It seems necessary to assume that the able men of a great race were drawn to Oxford and Cambridge rather than that an



NEVILLE COURT, TRINITY COLLEGE.

obsolescent system of education was responsible for their performance.

Oxford and Cambridge have already been reformed by act of parliament, and it is now proposed to repeat the performance with the labor party as the power behind the British throne, rather than men such as Larmor, the mathematical physicist, who represents Cambridge in the conservative interest in parliament. The announcement of the plans of the government were made by Mr. Fisher, a former university professor, now minister for education, to a deputation from the educational committee of the Parliamentary Labor Party, which urged the desirability of an inquiry into every aspect of the two universities. Mr. Fisher informed the deputation that the authorities of both universities had agreed to the principle of the inquiry. He gave an undertaking that the government would carefully consider the question of the representation of the labor movement and of women on the commissions.

The labor members, in presenting their demands, suggested that the scope of the inquiry should be so wide as to include the finance of the two universities, their endowments, constitution and government, and their relation to other parts of the national system of education, including the education of women. The deputation reminded Mr. Fisher that since the last public inquiry into the two universities the educational system had been revolutionized. Further, the number of students who could profit by study at Oxford and Cambridge had largely increased. The deputation declared that the labor movement desired that every man and woman capable of pursuing an education at the two universities to good account should be able to obtain it. They suggested that the end of the war was a specially suitable time for the inquiry which they

sought, and declared that the financial arrangements of Oxford and Cambridge offered *prima facie* some ground for believing that considerable economies would be made possible by a better system of administration—for example, by the greater centralization of the revenues now received by the colleges.

A demand was made for a thorough overhauling of the administration of the colleges with a view to diminishing the cost of living in college, which they estimated to be rarely less, and generally considerably more, than £100 for six or seven months' residence and education. That, it was contended, excluded the sons of men of small means, unless they were assisted by scholarships or exhibitions. The deputation definitely asserted that no systematic effort had been made by all college authorities to reduce the cost of residence and education to the lowest point compatible with efficiency. It was added that working people did not accuse college authorities of any deliberate policy of exclusiveness.

The deputation also asked for the thorough overhauling of the present system of awarding scholarships and exhibitions. It was stated that working people thought it highly improper that a money prize for a term of years should be awarded to a man who did not require it when so many men were debarred by financial difficulties from receiving a university education. Their view was that scholarships should be used to assist men who without assistance would be unable to meet the cost of an Oxford or Cambridge education.

Among other recommendations the deputation proposed that the constitution and government of the two universities should be reformed in such a way as to create a central body in each which would have effective control over the whole of the revenues and would compel the col-

leges to submit to its requirements—for example, in reducing the cost of living and in appointing lecturers and fellows. They also pressed for the inclusion on the governing body of each university of the representatives of the outside public, nominated by the Board of Education or otherwise, and for the abolition of the power of convocations to veto university legislation. Other points to which the labor deputation attached importance were the granting of degrees to women and the development of extra-mural university education.

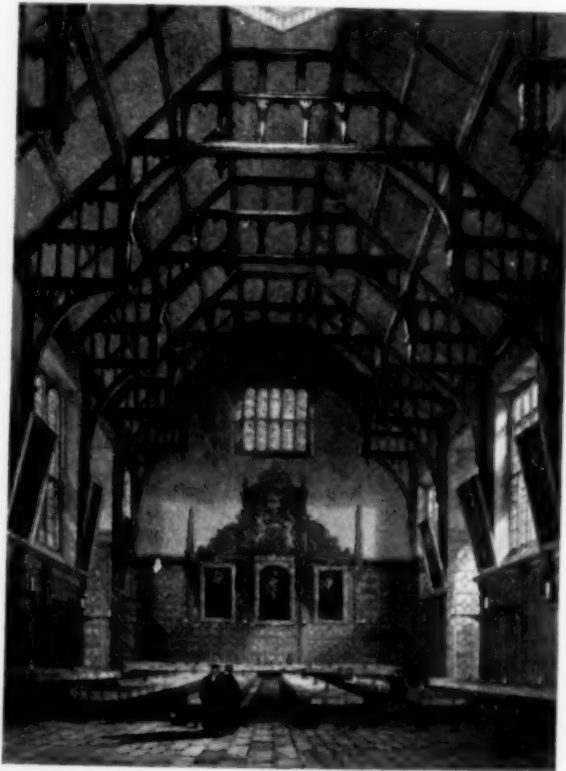
Finally, the deputation assured Mr. Fisher that labor was strongly in favor of a far larger public expenditure upon universities as upon

all other kinds of education. But they contended that, until Oxford and Cambridge were reformed, they could not properly be assisted by the grant of public money.

SCIENTIFIC ITEMS

WE record with regret the death of Gustaf Retzius, the eminent Swedish anatomist and anthropologist. Professor Retzius's father and grandfather were also distinguished Swedish professors of natural history and anatomy.

DR. THEODORE W. RICHARDS, professor of chemistry at Harvard University, has been elected president of the American Academy of Arts and Sciences. Professor Alexander



THE HALL OF TRINITY COLLEGE.

Smith, head of the department of chemistry at Columbia University, has been granted the degree of doctor of laws by the University of Edinburgh.

THE will of the late Andrew Carnegie was filed on August 28. Mr. Carnegie's gifts to charity during his life are said to have exceeded \$350,000,000. The value of his estate is estimated at between \$25,000,000 and \$30,000,000. The will contains a series of legacies, the most

substantial of which are to educational institutions. The Carnegie Corporation of New York. He is the residuary legatee.—It is announced that Yale University will receive approximately \$18,000,000, about \$3,000,000 in excess of the expectation of the university corporation, from the estate of John W. Sterling.—Edward F. Searles, of San Francisco, has given stock valued at \$1,500,000 to the University of California for its unrestricted use.